COST ALLOCATION STUDY

for the

MONTANA STATE HIGHWAY SYSTEM

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EXECUTIVE SUMMARY

The objective of this project was to review motor vehicle related revenues and highway expenditures in the state of Montana and suggest revisions to the revenue system, as necessary, so that highway costs are paid by motor vehicle operators in proportion to their use of the highway system. The project was divided into two tasks:

1) the performance of a cost allocation study comparing highway revenues collected from specific users with the costs occasioned in providing them with highway service. The objective of this study was to determine if all users are equitably sharing highway costs.

2) the investigation of Montana road user tax policy, subsidies, and vehicle tax/fee/permit schedules. The objective of this investigation is to formulate recommendations, as appropriate, to improve the motor vehicle tax system and to address any inequities in the system identified in the cost allocation study.

Initial effort focused on the first task, that is, the completion of a basic cost allocation study, and this report documents the results of this effort. Work is still underway on the second task and will be documented in a separate report.

This cost allocation study specifically addressed the relative equity of the taxes and fees paid by various highway users to the state of Montana with respect to the expenditures by the state to provide these users with highway service. Highway revenue collected and spent by the federal government was not included in the study. The study considered equity between three broad categories of vehicles, namely, basic, intermediate, and heavy vehicles. Basic vehicles included automobiles, motorcycles, vans, pickups, and any other vehicle with a gross weight less than 10,000 pounds. Intermediate vehicles generally consisted of busses and single unit trucks with two axles and average operating weights less than 26,000 pounds. Heavy vehicles generally consisted of those vehicles with operating weights in excess of 26,000 pounds and included single unit trucks with three or more axles and all truck and trailer combinations. To assess the relative equity of the motor vehicle tax structure, state revenues and expenditures on the highway system over a 4 year period (1988 to 1991) were analyzed and allocated to these three classes of users. An average equity ratio, defined as the ratio of allocated revenue to allocated costs, was calculated for each user group.

Equity ratios less than one indicated under payment by that group for use of the system; correspondingly, equity ratios greater than one indicated over payment for use of the system.

Over the four year study period, it was determined that basic, intermediate, and heavy vehicles were responsible for 64, 10, and 26 percent of highway revenues, respectively. The primary highway revenue considered in the study consisted of (a) collections from gross weight fees, the new car sales tax, and fuel taxes, and (b) disbursements from the coal tax trust fund and the proceeds of bond sales and bond interest. Conceptually, allocation of the former type of revenue, which was directly derived from users, was straight forward. These revenues were allocated to the three classes of vehicles in the manner in which they were collected. The latter type of revenue, of a more general source, was allocated presuming the intent was to provide equal benefit and service to all users. Thus, these revenues were shared "equally" between users based on the relative vehicle miles travelled on the highway system by each class of vehicle.

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent, respectively, of the state expenditures on the highway system over the study period. The major highway expenditures considered herein included the costs of the general operation of the Department of Transportation, operation of the Motor Carrier Services Division, highway construction, highway maintenance, bond principal and interest payments, and operation of the highway patrol. Several different methods were used to allocate these costs to the three vehicle classes, based on the specific activities associated with the expenditures involved. Generally, the costs of activities that were independent of the specific vehicle involved were allocated based on relative miles traveled by each class of vehicles. An example of such an activity/cost is the cost associated with signs and traffic signals. Costs that were influenced by the specific characteristics of the vehicles using the system were assigned, as possible, to each user class based on that characteristic of the vehicle. An example of such an item is the cost associated with winter sanding. The frequency that sanding must be repeated in the winter was judged to be related to the number of axle passages rather than the number of vehicle passages over a section of road. Thus, sanding costs were allocated to the vehicle classes based on the relative number of axle miles travelled by each class.

Construction and maintenance costs were a significant part of the total expenditures on the highway system (approximately 66 percent). Construction costs were analyzed using a basic facility approach. The cost of a highway to carry only basic vehicle traffic was uniformly shared across all users based on vehicle miles traveled. Additional costs to carry heavier traffic and vehicle loads were simply added to this cost and were allocated based on the relative physical demand placed on the

pavement by the vehicles in the various user classes (physical demand was quantified using the AASHTO ESAL concept). Pavement maintenance costs were split into costs occasioned due to weathering and aging related deterioration of the pavement and load related deterioration of the pavement. Weather and aging related costs were shared among users based on the relative miles travelled by each user class; costs associated with load related deterioration were allocated based on the physical demand placed on the pavement by the various vehicle classes. Allocation of both construction and maintenance costs was done individually for each study year and independently for interstate, primary, urban, and secondary highways.

The equity ratios determined from the allocation of state revenues and expenditures on the highway system were 0.96, 1.11, and 1.07, respectively, for basic, intermediate, and heavy vehicles. Thus, basic vehicles relatively under paid for their use of the highway system, while intermediate and heavy vehicles relatively over paid for their use of the system. These results are reasonable, based on the results of cost allocation studies conducted in other states. In evaluating these results, it is important to recognize that these ratios only indicate relative equity between user classes; they do not indicate if the absolute amount of revenue collected is sufficient to cover the absolute amount of expenditures. In the last two years of the study period (1990 and 1991), absolute expenditures on the highway system significantly exceeded revenues.

While these results were determined based on four years of historical data, it is believed they reflect revenue and expenditure patterns that will be valid over the next few years. Note that the Surface Transportation Act passed by the federal government in early 1992 will have an impact on the highway system. This impact is expected to be gradual.

Approaches to modifying the revenue structure to address the inequities in user payments found in this study were tentatively explored. A 400 percent increase in the new vehicle sales tax, for example, resulted in equity ratios between 0.98 and 1.01 for all vehicle classes. Alternatively, increasing the gasoline tax by 22.5 percent ($0.045 per gallon increase) resulted in equity ratios of approximately 0.98 for basic and heavy vehicles. The equity ratio for intermediate vehicles, however, increased from 1.11 to 1.14 in response to this action. Formal recommendations for changing the tax structure can not be formulated without completing a thorough review of the entire motor vehicle revenue structure.

ACKNOWLEDGEMENTS

An advisory committee was formed at the beginning of this investigation to review the study methodology and provide a broad perspective on various study issues. In addition to the authors of the study, committee members included Glenna Obie from AAA Montana, Ben Haavdahl from the Montana Motor Carriers Association, and David Galt from the Montana Department of Transportation. The participation of these individuals in the study process is gratefully acknowledged. The advice and encouragement provided by Keenan Bingham and Robert Garber at the Montana Department of Transportation is also gratefully acknowledged. Without exception, the response of the various divisions of the Montana Department of Transportation to requests for information to support the study were courteous, prompt, and professional.

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INTRODUCTION

General Remarks

Traditionally, of the many services provided by government, the highway system is partially or completely paid for by the people that use it. User fees take several forms, including fees related to the amount of use and level of demand a vehicle places on the system (e.g., fuel taxes and gross weight fees, respectively) and fees independent of these parameters (e.g., flat registration fees). The monies collected from the users, possibly supplemented by public funds of a more general source, are then spent to build and maintain the highway system in such a fashion as to provide an equal service and benefit to all. Under an equitable fee system, the monies collected from (and/or associated with) each user will be equal to the expense of providing that user with highway service. The fairness of the fee structure can be determined by comparing revenues to expenditures for various classes of users. Investigations of this kind are commonly referred to as motor vehicle cost allocation studies or cost responsibility studies. The most recent cost allocation study for Montana was conducted in 1957 (Johnson, 1957). As highway use and expenditure patterns can change over time, the 1991 Montana state legislature requested that a new cost allocation study be conducted. The results of this study will be considered in determining changes in the motor vehicle fees collected by the state of Montana.

Objective and Scope

The objectives of this project are to:

1) conduct a cost allocation study for the state highway system to determine if highway costs are equitably shared by vehicle operators in proportion to their use of the highway system.
2) to review the motor vehicle fee structure in the state of Montana and recommend appropriate changes based on present patterns of highway use, the results of the cost allocation study, and current practice nationwide.

Initial effort focused on the first objective, that is, the completion of a basic cost allocation study. The results of this study are presented in this report. Work on the second objective, developing recommendations for revising the motor vehicle fee structure, is underway and will be documented in a second report.

The cost allocation study conducted in this investigation specifically addressed the relative equity of the highway fees paid by motor vehicle operators to the state of Montana, independent of fees paid to the federal government. Correspondingly, the study only considered state revenues and state expenditures on the highway system in evaluating the equity situation. To conduct the study, these revenues and expenditures over a four year period (1988 to 1991) were allocated to three broad classifications of highway user, namely, basic (light) vehicles, intermediate vehicles, and heavy vehicles. An average equity ratio, defined as the ratio of allocated revenue to allocated expenditures, was calculated for each vehicle class. The equity ratios calculated for basic, intermediate, and heavy vehicles were 0.96, 1.11, and 1.07, respectively. Thus, basic vehicles were found to be nominally under paying for their use of the highway system; intermediate vehicles and heavy vehicles, nominally over paying for their use of the system.

STUDY DATA AND METHODOLOGY

General Remarks

The steps involved in conducting a cost allocation study consist of:

1) defining the highway system to be considered,
2) identifying the various users of this system and quantifying their level of demand,
3) identifying the source and amount of revenues and expenditures on the system,
4) allocating these revenues and expenditures to various users, and
5) comparing revenue and expenditures by user type to determine equity.

Information on the highway system, highway users, and revenues and expenditures was generally provided by the Montana Department of Transportation (MDT). Approaches for allocating revenues and expenditures to various vehicles were determined after extensive review of the available literature on cost allocation studies.

Highway System

This study was specifically concerned with those highways in the state of Montana for which the MDT assumes responsibility. In 1991, MDT participated in the operation and maintenance of approximately 12,900 miles of highways. A summary of these highways is presented in Table 1 in terms of both their federal aid and functional classification. The exact mileage of highways in the state inventory continually changes, as routes are upgraded, downgraded, re-built, and added or dropped from the system in response to changing traffic demands. A comparison of the mileage reported in each unit of the system in 1989 and 1991 indicated little change (less than 0.1 percent) in the system configuration over the four year study period (MDT, 1989 and 1991). Note that approximately 11,800 miles of highway in the state system (91 percent) is included in the federal aid system. The federal government will share the cost of certain activities on federal aid highways with the state. In general, major reconstruction and rehabilitation work qualify for cost sharing, with the federal government paying 80 to 90 percent of the total cost of such projects.

For the cost allocation study, highway use and expenditures were analyzed, as appropriate, on each unit of the federal aid system. Any differences in traffic patterns or in construction and maintenance philosophies between the systems thus were incorporated in the study. While

Table 1. State Highway System Mileage by Federal Aid System and Functional Class.

Federal Aid System	Functional Class					
	Interstate	Principal Arterial	Minor Arterial	Major Collector	Off System	TOTAL
Interstate						
Rural	1144					1144
Urban	47					47
Total	1191					1191
Primary						
Rural		2102	3249			5351
Urban		101				101
Total		2203	3249			5452
Secondary				4756		4756
Urban		70	190	101		361
Off System					1139	1139
TOTAL	1191	2273	3439	4857	1139	12899

Source: 1991 Montana Federal Aid Road Log (MDT, 1991)

differences in use and expenditures between various highways may be more closely and rationally tied to functional class than federal aid class, data were found to be readily available by federal aid classification. Note that in Montana, functional and federal aid classifications are closely correlated.

Highway Users

Three primary classifications of highway user were considered in this study, namely, basic vehicles, intermediate vehicles, and heavy vehicles. Basic vehicles consisted of passenger cars, pickups, vans, and recreational vehicles with registered gross weights of less than 10,000 pounds. Intermediate vehicles consisted of 2 axle single units and busses with registered weights generally greater than or equal to 10,000 pounds but less than 26,000 pounds. Heavy vehicles included all 3 or more axle single units with registered weights generally greater than or equal to 26,000 pounds and all combinations of power units or trucks with trailers. Information on highway use for these classes of vehicles was provided by the Traffic Data Collection Section of MDT. MDT monitors highway

use by vehicle configuration, using the 21 configurations listed in Table 2. The assignment of these configurations to the vehicle classifications used for the cost allocation study are also shown in Table 2.

Highway use can be expressed in terms of several parameters, including vehicle miles travelled (VMT), axle miles traveled (AMT), ton miles traveled (TMT), and ESAL miles traveled (ESAL-M). VMT is simply the number of vehicles on a highway multiplied by the miles they travel over some time interval. If additional information is available concerning specific characteristics of the vehicles, AMT, TMT and ESAL-M can be calculated from VMT. For a specific vehicle configuration, AMT can be calculated as the number of axles for that vehicle type multiplied by its VMT. Similarly, if weight data is available, TMT can be simply calculated as the weight per vehicle (in tons) multiplied by its VMT. ESAL-M can also be calculated by multiplying the ESAL factor for a vehicle by its VMT. The ESAL factor for a vehicle is an indication of the physical demand that the passage of that vehicle places on the roadway (particularly on the base and wearing surface). The ESAL concept was developed for design purposes to calculate a design demand on a roadway subjected to a mixed stream of vehicles. The ESAL factor of a vehicle is related to both the type of axles on the vehicle, the loads they carry, and the type of pavement on which the vehicle is operated. The factor represents the number of passages of an 18,000 pound single axle that would damage the pavement an amount equivalent to the single passage of the vehicle in question (equivalent single axle load, ESAL). For a particular vehicle, the ESAL factor is calculated as the sum of the ESAL values for each axle comprising the vehicle. Relationships between axle loads and ESALs were developed from the results of the AASHO Road Test (Highway Research Board, 1962). The relationship between ESAL factor and axle load is non-linear, that is, as axle load increases, the ESAL factor increases in a fourth order relationship.

The traffic data used in this study is summarized in Tables 3 and 4. Data was only available for 1988, 1989, and 1990 at the time the study was initiated (the 1991 traffic data was still being processed). The 1990 data was used for 1991 throughout the study. This approximation is believed to have only nominally effected the study results. Note that in most applications, the study utilized the relative proportion of different types of vehicles in the traffic stream, rather than the absolute volume of traffic.

Data on highway use is collected through vehicle counts, classification surveys, and weigh station activities. For the interstate and primary systems, information obtained by MDT from visual classification counts conducted simultaneously with weight measurements was most useful. The data

Table 2. User Classifications (Vehicle Configurations).

Description	Average Operating Weight, lbs	Number of Axles	Average Operating ESALs
Basic Vehicles			
Pass. Car,	2,500	2	0.0002
Light Truck, Vans, RV	6,000	2	0.0023
Intermediate Vehicles			
Busses	25,000	3	0.257
2 Axle/4 Tire	12,000	2	0.0342
2 Axle/6 Tire	15,960	2	0.344
Heavy Vehicles			
3 Axle, Single Unit	30,160	3	0.607
4+Axle, Single Unit	52,080	4+	1.392
3 Axle Semi	28,100	3	0.643
4 Axle Semi	32,248	4	0.548
5 Axle Semi	64,390	5	1.527
6 Axle Semi	68,462	6	1.691
3 Axle Trk, Full Tr	19,500	3	0.314
4 Axle Trk, Full Tr	23,260	4	0.289
5 Axle Trk, Full Tr	69,000	5	1.965
6 Axle Trk, Full Tr	72,489	6	1.468
5 Axle Semi, Full Tr	64,489	5	1.980
6 Axle Semi, Full Tr	62,571	6	1.414
7 Axle Semi, Full Tr	78,710	7	1.825
8 Axle Semi, Full Tr	91,401	8	1.574
7 Axle, Triple Tr	86,976	7	2.498
8 Axle, Triple Tr	88,976	8	2.918

consisted of traffic counts broken down by vehicle configuration coupled with the average weight carried on each axle of each configuration. The weight data was used to calculate average operating weights and ESAL factors for each vehicle configuration (see Table 2). The vehicle ESAL factors were calculated as the sum of the axle ESAL factors, which were determined using the AASHTO Guide for Design of Pavement Structures (AASHTO, 1986) assuming a flexible pavement with a structural number (SN) of 5 and a terminal serviceability of 2.5. The ESAL factors for each vehicle

configuration and year were averaged to obtain the factors used in calculating ESAL-M for each year of the study from VMT.

Referring to Table 3, vehicle use of the highway system gradually increased between 1988 and 1990 (recognizing that the physical miles of highway in the system was approximately the same over all years). The relative proportion of basic, intermediate, and heavy vehicle traffic, however, remained fairly constant during this time. Basic vehicles were responsible for the majority of VMT (84 percent). Intermediate and heavy vehicles were only responsible for 7 and 9 percent of VMT, respectively. Conversely, basic vehicles were only responsible for 1 percent of ESAL-M, compared to 11 percent for intermediate vehicles and 88 percent for heavy vehicles.

From Table 4, most of the vehicular use of the highway system in terms of miles travelled was on the rural primary and interstate systems. The primary rural system accounted for 40 percent of total VMT and TMT, and 39 percent of ESAL-M. The rural interstate system accounted for only 30 percent of VMT, 40 percent of TMT, and 47 percent of ESAL-M. Note that the data available for secondary roads was sparse, and the values listed in Table 4 for secondary roads are considerably less certain than those for primary roads and the interstate.

Study Period

Four years of historical revenue and expenditure data were considered in performing this cost allocation study. By considering several years in the study period, the influence of episodic fluctuations in spending and system use on the study results were minimized. The four years selected for the study were fiscal years 1988 through 1991. Construction of possibly the last new major highway system in Montana (the interstate system) was completed in 1988. Beginning in 1988 and extending into the years thereafter, expenditures focused on reconstruction and maintenance betterment activities, a pattern which is expected to continue for at least the next few years (Kologi and Bingham, 1992). Based on the uniformity of the traffic data for 1988 to 1990, radical changes in vehicle types and traffic patterns are not expected in the near future.

One factor that will have a long term impact on the highway system in Montana is the Surface Transportation Act passed by the federal government in early 1992. The federal aid highway system was re-organized under this act, altering the status of several specific routes within the state. The act also established new state/federal cost share ratios for reconstruction work on the federal aid highways. The total aid available from the federal government for cost shared projects will also increase compared to previous years. While all the ramifications of the act are still being investigated,

its impact on the highway system and highway funding is expected to be gradual (Kologi and Bingham, 1992).

Table 3. Summary of Traffic Data by Years, All Systems.

Measure of Use	Average Daily Use		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
1988			
VMT	13,161,601	1,126,417	1,392,800
TON-M	25,356,645	8,713,623	38,725,137
AXLE-M	26,333,946	2,467,740	6,699,100
ESAL-M	13,201	241,213	1,847,420
1989			
VMT	13,720,732	1,176,244	1,459,920
TON-M	26,330,183	9,071,266	40,533,884
AXLE-M	27,359,386	2,560,668	7,009,790
ESAL-M	13,701	248,202	1,937,257
1990			
VMT	14,077,284	1,210,723	1,505,199
TON-M	26,961,659	9,261,102	41,794,371
AXLE-M	28,049,516	2,624,208	7,219,779
ESAL-M	13,971	252,013	1,996,143

Source: Traffic Data Collection Section, MDT

Table 4. Average Traffic Over the Study Period by Federal-Aid System.

Federal Aid System	Average Daily Use			
	VMT	TMT	AMT	ESAL-M
Interstate				
Rural	4,751,554	30,308,793	11,622,460	1,018,494
Urban	414,669	2,326,876	989,059	82,951
Primary				
Rural	6,719,110	29,966,512	15,101,879	848,944
Urban	1,128,310	3,300,737	2,363,351	60,808
Secondary	1,424,989	5,667,125	2,998,668	150,510
Urban	1,838,342	4,012,580	3,699,295	25,999

Revenue and Expenditures

Basic data on highway department revenues and expenditures over the 4 year study period were provided by the Financial Management Bureau of MDT. A summary of this information is presented in Table 5; the complete cash flow table from which this information was obtained is presented in Appendix A. Note, once again, that the revenues and expenditures considered in this study are only the state share of monies collected and spent on the state highway system. The federal government collects significant highway user fees and is a major source of construction funds for highways included in the state system. The state of Montana, however, has only nominal influence on the federal highway revenue system and construction expenditure program. Furthermore, the state and federal governments maintain a clear distinction between their fiscal systems. In light of this situation, revenues and expenditures by the state on the highway system can be reasonably studied independently of those of the federal government.

Allocation Process

This cost allocation study was conducted by assigning the highway revenues and expenditures listed in Table 5 to the various classes of vehicles responsible for them. Commonly used allocation techniques are described in such documents as the "State Guide to Highway Cost Allocation" published by the Federal Highway Administration (FHWA, 1984) and the "Rationalization of Procedures for Highway Cost Allocation" by the Urban Institute, et. al. (1990). Specific implementation of these approaches is well documented in the various cost allocation studies completed by states around the nation. A federal survey conducted in 1990 (AASHTO, 1990) found that 21 states had completed cost allocation studies between 1977 and 1990 and that 7 other states had studies underway. Some states (e.g., Oregon and Nevada) routinely revise their studies in acknowledgement of the dynamic nature of highway use and expenditures.

Conceptually, allocation of most revenue was straight forward, in that the revenue was assigned to those vehicles from which it was collected. Practically, revenue allocation is complicated by the fact that most accounting systems maintain records of total revenue collected and not the specific source of this revenue. For example, while $67,014,519 in gas tax revenue is listed in Table 5 for FY '88, no direct record exists if this revenue was collected from compact cars (basic vehicle) or busses (intermediate vehicle). Therefore, indirect methods were often employed in the revenue allocation process.

Table 5. Revenue and Expenditure Data for the Cost Allocation Study.

Item	FY '88	FY '89	FY '90	FY '91
Beginning Cash Balance	$126,618,131	$141,623,591	$146,222,162	$129,913,204
REVENUE				
Gross Weight Fees	13,335,103	13,930,613	14,484,637	14,163,160
Sales Tax on New Vehicles	5,503,227	6,271,576	7,041,066	6,269,773
Miscellaneous Fees Collected by M.C.S. Division	5,136,417	5,071,764	5,212,522	4,743,787
Gasoline Fuel Tax	67,014,519	70,069,172	69,739,270	68,551,154
Diesel Fuel Tax	19,699,828	21,184,583	22,233,781	21,246,525
Coal Tax Trust Fund	10,156,597	7,027,869	8,144,464	6,054,941
Bond Proceeds and Earnings	9,080,153	6,200,687	3,925,575	725,549
Miscellaneous Accounts Receiveable	2,094,154	2,075,961	4,912,125	3,673,793
ACI Reimbursement	7,489,996	0	0	0
Supplement from Cash Balance	0	0	16,308,422	39,238,516
TOTAL REVENUE	$139,509,994	$131,832,225	$152,001,862	$164,667,198
EXPENDITURES				
M.C.S. Division Operations	3,392,515	3,377,012	3,370,452	3,485,987
General Operations	8,725,947	6,840,035	7,059,402	7,359,166
Pre-Construction	3,847,939	4,607,207	5,028,133	6,737,771
Construction	46,999,540	53,336,864	70,342,059	81,714,233
Maintenance	40,968,264	42,121,180	44,480,936	45,863,441
Bond Principal and Interest	10,041,082	10,041,083	10,041,083	9,741,178
Dept. of Justice	9,708,600	9,957,471	10,885,348	10,987,488
Misc. Expenditures	820,917	(3,046,662)	794,449	(1,222,066)
TOTAL EXPENDITURES	$124,504,534	$127,234,190	$152,001,862	$164,667,198
Contribution to Cash Balance	15,005,460	4,598,035	0	0
TOTAL	139,509,994	131,832,225	152,001,862	164,667,198

Several different methods were employed to allocate highway expenditures to the various classes of vehicles, based on the activities associated with the expenditures involved. Generally, the costs of activities that were independent of the specific vehicle involved were allocated based on VMT. An example of such an activity/cost is the cost associated with road signs. Costs occasioned by demands related to specific attributes of vehicles were allocated, as possible, based on that attribute. The frequency that sanding must be repeated in the winter, for example, was judged to be related to the number of axle passages rather than the number of vehicle passages. Thus, sanding was allocated based on AMT.

Throughout this report, allocation strategies employed in other studies are cited with respect to those selected for use in this study. The results obtained in other states from the allocation process are compared, as possible, with the results obtained herein.

REVENUE ALLOCATION

General Remarks

Basic, intermediate, and heavy vehicles were found to be responsible for 64, 10, and 26 percent of state highway revenues, respectively. The allocation of specific types of revenue to the three vehicle classes is summarized in Table 6. The allocation factors used in each year of the study

Table 6. Summary of Revenue Allocation.

Source	Avg. Annual Revenue, FY 88-91	Allocation Methodology	% Basic	% Inter.	% Heavy
Gross Weight Fees	$13,978,378	To various vehicle categories as collected	14	12	74
Sales Tax on New Vehicles	6,271,411	To various vehicle categories as collected	88	4	8
Misc. Fees Collected by Motor Carrier Services	5,041,123	To intermediate and heavy vehicles based on AMT	0	27	73
Gasoline Fuel Tax	68,843,529	To all vehicles based on expected mpg and VMT	86	12	2
Diesel Fuel Tax	21,091,179	To all vehicles based on expected mpg and VMT	8	6	86
Coal Tax Trust Fund	7,845,968	To all vehicles based on VMT	84	7	9
Bond Proceeds and Earnings	4,982,991	To all vehicles based on VMT	84	7	9
Miscellaneous Accts Receiveable	3,189,008	To all vehicles based on VMT	84	7	9
ACI Reimbursement	1,872,499	To all vehicles based on construction cost responsibility	65	9	26
Supplement from Cash Balance	13,886,734	To all vehicles as contributed to cash balance	77	8	15
TOTAL	147,002,820	-	**64**	**10**	**26**

period for the different types of revenue are listed in Table 7. The revenue considered for allocation in this study can be divided into two broad categories, namely, (1) fees paid directly by users, consisting of fuel taxes, the new vehicle sales tax, and weight taxes, and (2) revenue not derived from specific users, consisting of interest earnings on bonds, revenue from the Coal Tax Trust Fund, etc. Over the four year study period, the average annual revenue collected was $131,116,085 dollars. Approximately 90 percent of this revenue was from direct user fees; 10 percent, from non-specific sources. As possible, direct user fees were allocated as they were collected. Non-specific fees were generally allocated by VMT to all users. Note that in 1988 and 1989, revenues exceeded expenditures, and thus money was contributed to the MDT working cash balance. Conversely, in 1991 and 1992, expenditures exceeded revenues, and monies had to be withdrawn from the working cash balance.

Allocation of Fuel Taxes

Gasoline and diesel fuel tax revenue was allocated to the three vehicle classes based on estimates of fuel consumption rates and distance travelled. As might be expected, basic vehicles were responsible for most of the gasoline tax revenue (86 percent), while heavy vehicles were responsible for most of the diesel tax revenue (86 percent). The current fuel tax in Montana is $0.20 per gallon of gasoline and diesel fuel (Montana Code Annotated (M.C.A.), 1991). The information available on fuel tax revenue simply consisted of the total gallons taxed and total revenue collected each year, as shown in Table 8.

A portion of the fuel tax revenue is passed through MDT to cities and counties for use on local roads. The fuel tax revenue reported in the cash flow sheet in Appendix A was reduced by this amount (approximately $14,146,250 annually). The majority of this local road disbursement (approximately 75 percent) was deducted from the gasoline tax revenue. The assumption was made that lighter gasoline powered vehicles were responsible for more of the use of local roads than heavier diesel powered vehicles. Initially, two approaches were considered for deducting the local road disbursement, namely, (a) deducting the disbursement entirely from gasoline tax revenues, and (b) deducting the disbursement from gasoline and diesel fuel revenues in the proportion in which the taxes on these fuels were collected. Finally, the local road disbursement was divided between gasoline and diesel fuel using the average of the results obtained from these two approaches.

The first step in allocating fuel revenues was to estimate the percentage of each vehicle configuration that used gasoline versus diesel fuel. The miles travelled by each vehicle type using

Table 7. Revenue Allocation by Study Year.

Revenue	Allocation, 1988			Allocation, 1989			Allocation, 1990			Allocation, 1991			Allocation, Over-all		
	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV
Gross Weight Fees	0.14	0.13	0.73	0.13	0.12	0.75	0.13	0.11	0.76	0.14	0.13	0.73	0.14	0.12	0.74
Sales Tax on New Vehicles	0.88	0.03	0.09	0.88	0.03	0.09	0.89	0.04	0.07	0.88	0.05	0.07	0.88	0.04	0.08
Misc. Fees Collected by M.C.S. Division	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73
Gasoline Fuel Tax	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02
Diesel Fuel Tax	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86
Coal Tax Trust Fund	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Bond Proceeds and Earnings	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Miscellaneous Accounts Receiveable	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
ACI Reimbursement	0.65	0.09	0.26	+	+	+	+	+	+	+	+	+	0.65	0.09	0.26
Supplement from Cash Balance	*	*	*	*	*	*	0.77	0.08	0.15	0.77	0.08	0.15	0.77	0.08	0.15
Total Revenue	0.64	0.10	0.26	0.62	0.11	0.27	0.64	0.10	0.26	0.65	0.10	0.25	0.64	0.10	0.26

BV - Basic Vehicle
IV - Intermediate Vehicle
HV - Heavy Vehicle
* - No supplement was required
+ - No revenue

Table 8. Summary of Fuel Tax Revenues.

Fiscal Year	Gasoline		Diesel	
	Taxable Gallons	Total Tax	Taxable Gallons	Total Tax
1988	443,275,215	$85,576,181	115,431,120	$22,389,970
1989	442,819,163	88,563,833	117,149,919	23,429,984
1990	444,634,725	88,926,945	122,858,459	24,571,692
1991	437,859,988	87,571,998	118,384,584	23,676,917

Source: Accounting Services, MDT (Miros, 1992)

gasoline and diesel fuel were calculated based on these percentages. Estimates of the gallons of fuel used by each vehicle configuration were then obtained by dividing the miles travelled using each fuel type by the expected miles per gallon for that vehicle configuration. Projected tax revenues from each vehicle type were calculated by multiplying the estimated gallons consumed by the $0.20 per gallon tax rate. Fuel tax revenue allocators were calculated as the ratio of the projected revenue from each vehicle class divided by the total projected revenue. Finally, the fuel tax revenue allocated to each vehicle class each year was determined by multiplying the actual annual fuel tax revenue by these revenue allocators.

Estimates of the percentage of each vehicle configuration that used gasoline and diesel fuel were found in the 1987 California Cost Allocation Study (Sydec, 1987) and are presented in Table 9. These estimates apparently were based on forecasts presented in an earlier report by Systems Design Concepts, Inc. (1981). The percentage of gasoline versus diesel vehicles within each vehicle configuration were also estimated from information presented in the State Highway Cost-Allocation Guide prepared by the Federal Highway Administration (1984); these estimates are also presented in Table 9. The splits between gasoline and diesel vehicles reported by these two sources are generally similar. The split from the California Highway Cost Allocation Study was used in this study, as the California study is nominally more current than the State Highway Cost-Allocation Guide, and the California split schedule is somewhat more complete. The vehicle miles travelled using gasoline and diesel fuel were simply calculated for each vehicle configuration by multiplying VMT by the appropriate factors in Table 9.

The gallons of gasoline and diesel fuel used by each vehicle configuration were estimated by dividing the miles travelled using that type of fuel by an estimated consumption rate (i.e. miles per

Table 9. Split, Gasoline Versus Diesel Fuel by Vehicle Configuration.

Vehicle Configuration	California Highway Cost Allocation Study (Sydec, 1987)		State Highway Cost-Allocation Guide (FHWA, 1984)	
	Percent Gasoline	Percent Diesel	Percent Gasoline	Percent Diesel
Autos	97.5	2.5	98.5	1.5
Motorcycles	100.0	0.0	100.0	0.0
Pickup, Van, Rv	97.0	3.0	98.5	1.5
Busses	73.5	26.5	83.0	17.0
SU - 2 Axle	88.0	12.0	93.0	7.0
SU - 3+ Axle	43.5	56.3	31.5	68.5
Comb. 3 Axle	23.5	76.5	0.0	100.0
Comb. 4 Axle	15.5	84.5		
Comb. 5+ Axle	2.0	98.0	0.0	100.0

gallon) for that configuration. Estimated fuel consumption rates presented in the California cost allocation study (Sydec, 1987) are presented in Table 10. Also presented in Table 10 are estimated fuel consumption rates determined from information presented in the State Highway Cost Allocation Guide (FHWA, 1984). While the miles per gallon generally decrease as vehicle size increases in both studies, considerable variation exists between the specific gasoline and diesel miles per gallon reported for various vehicles. Additional information on fuel consumption rates was obtained from Highway Statistics published by FHWA (1988, 1990) and is reported in Table 11. This information consisted of average miles per gallon (single value for both fuel types) by year. The miles per gallon values reported in Table 11 (similar to those reported in Table 10) were used in this study. The 1990 values were also used for 1991.

Based on the miles per gallon figures in Table 11, and VMT data for each vehicle configuration, the gallons of gasoline and diesel fuel used for travel on the state highway system by each user class were calculated. If the fuel tax revenue provided to local governments is converted to equivalent gallons of fuel used and added to these gallonages, the total estimates of gallons of gasoline and diesel fuel used each year are approximately 12 and 9 percent less than the actual gallons of gasoline and diesel fuel taxed each year (see Table 12). This difference at least partially represents the fuel used for non-highway related operations, particularly with respect to gasoline.

Table 10. Fuel Consumption Rates, Gasoline and Diesel Vehicles.

Vehicle Configuration	Miles per Gallon California Cost Study (Sydec, 1987)		Miles per Gallon State Highway Cost Allocation Guide (FHWA, 1984)	
	Gasoline	Diesel	Gasoline	Diesel
Autos	20.6*		16.6	28.4
Motorcycles	50.0*		50.0	-
Pickups, Vans, RVs	15.1*		14.3	17.9
Busses	5.2*		7.4	4.4
SU - 2 Axle	7.6	11.0	7.4	9.3
SU - 3+ Axle	5.0	5.3	6.0	4.9
Comb. 3 Axle	4.5	6.1	5.3*	
Comb. 4 Axle	4.4	5.6		
Comb. 5 Axle	4.2	5.2	-	4.6

SU - Single Unit
* - single value given

Table 11. Fuel Consumption Rates for 1988, 1989, and 1990.

Vehicle Configuration	Miles Per Gallon, Mixed Gasoline and Diesel Vehicles		
	1988	1989	1990
Passenger Cars	20.0	20.3	20.9
Busses	5.9	6.0	6.4
SU, 2 Axle, 4 Tire	13.4	13.8	14.1
Other SU	7.1	7.5	7.3
Combinations	5.3	5.5	5.5

SU - Single Unit
Source: Highway Statistics, 1988 and 1990 (FHWA, 1988, 1990)

Table 12. Comparison of Actual and Projected Gallons of Fuel Taxed.

Fuel Type	Actual Gallons Taxed (Annual Average)	Projected Gallons Taxed (Annual Average)			Ratio, Calculated to Actual Gallons Taxed
		From Analysis of State System Traffic Data	From Analysis of Local Government Allotment	Total Gallons From Analysis	
Gasoline	442,758,801	328,766,108	63,045,365	391,811,473	0.88
Diesel	119,832,102	101,035,600	7,685,885	108,721,485	0.91

Less non-highway consumption of diesel fuel might be expected than indicated herein, and the disparity in estimated and actual gallons of diesel fuel taxed may indicate inaccuracies in the consumption rates assumed for diesel powered vehicles.

The projected gallons of fuel consumed each year were multiplied by the $0.20 per gallon tax rate to obtain a projected tax revenue for each vehicle class. Allocators for the actual fuel tax revenue each year were calculated as the ratio of the projected revenue from each vehicle class to the total projected revenue.

New Vehicle Sales Tax

Revenue from the new vehicle sales tax was approximately allocated to the vehicles from which it was collected. Basic, intermediate, and heavy vehicles were assigned 88, 4, and 8 percent of the revenue collected over the study period. The new vehicle sales tax is collected on all sales of new motor vehicles (except trailers, semitrailers, and housetrailers) in consideration of the right to use the state highways (M.C.A., 1991). Depending on the type of vehicle and date purchased, this tax ranges from 0.004 to 0.015 of the list price of the vehicle. The available sales tax data is summarized in Table 13.

Sales tax collected on cars and motorcycles was allocated to basic vehicles. Taxes collected on truck sales were split between basic, intermediate, and heavy vehicles. From vehicle registration data for 1990 (Montana Department of Justice, 1991), approximately 89 percent of the trucks weighing less than 26,000 pounds were basic vehicles (gross vehicle weight of less than 10,000 pounds). Assuming vehicles of this size and type are generally replaced in the same proportion at which they are registered, approximately 89 percent of the new trucks purchased were basic vehicles. Further assuming that variations in list prices, tax rates, and replacement rates average out across this

Table 13. New Vehicle Sales Tax Data.

Fiscal Year	New Vehicle Sales Tax Collected				
	Total	Cars Motorcycles	Trucks under 26,000 lbs	Trucks over 26,000 lbs	Tractors
1988	$6,693,526	$4,468,892	$1,797,191	$84,523	$342,920
1989	6,596,721	4,197,223	1,940,904	73,620	384,974
1990	6,376,887	3,589,585	2,202,657	73,626	511,019
1991	5,771,130	2,591,925	2,617,634	*23,361	538,210

* possible error, calculations done using 1990 value
Source: Motor Carrier Services Division, MDT (Ala, 1992)

group of vehicles, 89 percent of the sales tax revenue collected from trucks weighing less than 26,000 pounds was assigned to basic vehicles. The remainder of the revenue from trucks weighing less than 26,000 pounds was assigned to intermediate vehicles. All of the revenue from trucks weighing at least 26,000 pounds and tractors was assigned to heavy vehicles.

Gross Weight Fees

Basic, intermediate, and heavy vehicles were assigned 14, 12, and 74 percent of the gross weight fees collected, respectively. Gross weight fees are collected annually on motortrucks, truck tractors, trailers, and semitrailers, as established by state law (M.C.A., 1991). The magnitude of the fees are generally related to the type and gross weight of the unit to be licensed. For vehicles with gross weights exceeding 24,000 pounds, annual fees can be prorated to the nearest month based on that part of the year that the vehicle will actually be used. The available data on gross weight revenues varied with the type of user from which it was collected. Different types of records were available for vehicles used only in Montana, vehicles based in Montana that were engaged in interstate travel, and vehicles engaged in interstate operation that were based out of state. The revenues collected from each of these types of user are summarized in Table 14. The allocators used in assigning this revenue to basic, intermediate, and heavy vehicles are summarized in Table 15.

Allocation of the gross weight fees to the vehicles from which they were collected proved to be a difficult task due to (a) the nature of fee system and (b) the available records. Power units and trailers are generally licensed separately in Montana. Thus, assigning revenue from such units to a

Table 14. Gross Weight Fees Collected During the Study Period.

Fiscal Year	Gross Weight Fees Collected			
	Montana Only*	Interstate, Based in Montana*	Interstate, Based Outside Montana	Total*
1988	$6,754,597	$2,898,152	$3,682,354	$13,335,103
1989	6,754,597	3,052,689	4,123,327	13,930,613
1990	6,733,374	2,948,977	4,802,286	14,484,637
1991	6,873,425	2,933,792	4,355,944	14,163,160

*Source: G.V.W. Division, MDT (Ala, 1992)

Table 15. Allocation of Gross Weight Fees by Source.

Fiscal Year	Montana Only Operators			Interstate Operators, Based in Montana			Interstate Operators, Based Outside Montana		
	BV	IV	HV	BV	IV	HV	BV	IV	HV
1988	0.28	0.23	0.49	0.00	0.04	0.96	0.00	0.00	1.00
1989	0.28	0.23	0.49	0.00	0.02	0.98	0.00	0.00	1.00
1990	0.27	0.22	0.51	0.01	0.06	0.93	0.00	0.00	1.00
1991	0.28	0.24	0.48	0.00	0.06	0.93	0.00	0.00	1.00

specific vehicle combination is uncertain, in that the units can be combined in several ways. The data available on the fees collected varied with the source of the revenue, ranging from a simple lump sum for hundreds of vehicles with no indication of specific source, to the individual fees paid on specific vehicles. Faced with these problems in assigning the gross weight revenue, the decision was made to simplify the allocation process by only attempting to allocate this revenue to the broad categories of basic, intermediate, and heavy vehicles.

The records available on the gross weight fees paid by vehicles that operated exclusively in Montana consisted of the total revenue collected each year and the number of units registered at various weights (in increments of 2,000 pounds) listed by type (truck or trailer) and fee class. This information was available for 1989, 1990, and 1991. The contributions from basic and intermediate vehicles were calculated by multiplying the number of vehicles in the various weight classes (6,000

and 8,000 pounds for basic vehicles and 10,000 to 24,000 for intermediate vehicles) by the corresponding annual fees for each weight class. Contributions from heavy vehicles could not be directly estimated using this procedure, as the fees collected from individual vehicles varied due to proration for partial year registration. Heavy vehicle contributions were simply calculated by subtracting the previously allocated basic and intermediate vehicle contributions from the total revenue collected. The results obtained by this procedure for 1989 were significantly different from those obtained for 1990 and 1991. Therefore, the 1989 fees (for this type of user) were assigned using the average of the percentages allocated to each vehicle class in 1990 and 1991. The revenue and allocation factors established for 1989 were also used for 1988, in the absence of any other information for 1988. Based on these various calculations and assumptions, an average of 28, 23, and 49 percent of this portion of the gross weight fees were assigned to basic, intermediate, and heavy vehicles.

The fee information available for interstate operators based in Montana was fairly detailed, consisting of the specific fees paid by each operator, the type of unit or units involved (single unit, bus, tractor, trailer, or double trailer), the registered weight of each unit, and the number of axles on each unit. Each year, a sampling of the registration fees paid by 65 operators (on a total of approximately 850 vehicles) was randomly selected and analyzed to determine the percentage of fees paid on each class of vehicles. Contributions from single unit trucks with gross weights of 6,000 and 8,000 pounds were assigned to basic vehicles. Intermediate vehicles were credited with those fees paid on 2 axle, single units and busses with weights between 10,000 and 24,000 pounds. All remaining contributions (from heavy single units, tractors, and trailers) were allocated to heavy vehicles. The average proportion of these gross weight revenues paid by basic, intermediate, and heavy vehicles were found to be 0, 5, and 95 percent.

Gross weight fee data for vehicle operators based outside Montana simply consisted of the total amount collected from each state on a monthly basis, and this information was only complete for 1991. Therefore, the amount of revenue generated from this group of vehicles each year was simply calculated by subtracting the revenue from instate and Montana based interstate operators from the total gross weight fees collected. The only information available to verify these figures was the total revenue collected from out-of-state operators in 1991, which was reported to be $5,503,035. This value is approximately 25 percent higher than that calculated by subtracting instate and Montana based interstate revenue from the reported total revenue for 1991. This discrepancy is still under investigation. All revenue from out-of-state operators was allocated to heavy vehicles. Under a

reciprocal fee arrangement, Montana does not collect gross weight fees for vehicles with weights less than 26,000 pounds. Note that an informal visual classification count conducted over a 4 hour period at the Haugan weigh station revealed that 98 percent of the out-of-state based truck traffic were combination units.

Total gross weight fee contributions for each vehicle class were determined each year by summing the contributions from in-state vehicles, interstate vehicles based in Montana, and vehicles engaged in interstate operations that were based out of state.

Coal Tax Trust Fund and Bond Related Revenues

The Coal Tax Trust Fund and Bond Related revenues are not associated with specific classifications of highway user. Presuming the intent of these contributions was to provide equal benefit to all users, it was decided to allocate this income based on VMT. Note that in the Maine cost allocation study (Maine DOT, 1989), a preliminary revenue analysis was performed considering only direct user contributions. The allocation factors determined from this analysis were used to apportion all non-specific revenues to various classes of user. The authors of the Vermont study apparently elected to exclude non-user specific revenues from consideration (Sydec, 1990).

Miscellaneous Motor Carrier Services Income

Miscellaneous revenue collected by the Motor Carrier Services division of MDT primarily consisted of permit fees and fines. These fees and fines were levied almost entirely on intermediate and heavy vehicles. This income was judged to be nominally related to the vehicle configuration as represented by the number of axles. Thus, miscellaneous Motor Carrier Services income was allocated based on AMT to intermediate and heavy vehicles.

Miscellaneous Accounts Receivable

Revenue not readily included in any area discussed above is accounted for in miscellaneous accounts receivable. While specific revenues included in this category vary somewhat from year-to-year, a typical list of accounts receivable for one year is presented in Table 16. These revenues were collectively allocated to various users based on VMT. Note that annual accounting adjustments and corrections to revenue are included in this category.

Table 16. Typical Revenue Included Under Accounts Receiveable (FY 1990).

Revenue Type	Revenue Amount
Sale of Property	$160,705
Leases	89,316
Miscellaneous Receipts	477,294
Transfers-In Coal Board	1,032,929
Administration Fees (Handling Charges)	12,248
Reimbursements	916,853
Administration Fees (Handling Charges)	40,679
City/County Reimbursement	2,021,160
Haugan GVW Scale	111,340
Coal Board Grants	9,188
Coal Board Grant II City/County	53,183
Coal Board Grant II	53,183
TOTAL	4,978,078

Source: MDT Financial Management Bureau (Kirby, 1992)

Advanced Construction Interstate (ACI) Reimbursement

The ACI revenue shown in Table 5 for 1988 consisted of a reimbursement from federal funding sources for state monies spent in previous years to accelerate the completion of the interstate system. As the original expenditures were generally on construction efforts, this reimbursement was allocated to the various classes of vehicles using the allocation factors for construction expenditures.

Supplement from Working Cash Balance

The beginning working cash balance for any given year represents the cumulative difference to-date between revenues and expenditures. At the beginning of FY 1988, the reported working cash balance was $126,618,131. A significant part of this cash balance resulted from the sales of bonds in FY 1987. It was important to consider the source and assignment of this cash balance to the various user classes, in that this cash balance served as income in years that expenditures exceeded revenues (as occurred in 1990 and 1991).

Basic, intermediate, and heavy vehicles were credited with 79, 8, and 13 percent, respectively of the beginning cash balance in FY 1988. Near the end of FY 1987, $150,000,000 in highway bonds were sold. After various fees were paid and outstanding debt retired and accounts consolidated, MDT realized approximately $99,000,000 of revenue from the sale and associated interest earnings. Approximately $3,400,000 of this money was spent in 1987. The remaining funds, $95,600,000 became part of the departmental working cash balance. This $95,600,000 was credited to each vehicle class based on the average VMT over the study period, consistent with the concept that the intent of the bond money was to provide equal service and benefit to all users of the highway system. In the absence of any information regarding the source of the remaining amount in the beginning cash balance, approximately $31,018,131, this money was allocated to various vehicle classes based on the over-all revenue allocators developed for 1988.

In 1988 and 1989, revenues continued to exceed expenditures, and the excess monies were added to the working cash balance. Each year, contributions to the cash balance were allocated based on the over-all allocation factors for the revenue collected that year, and the proportion of the new total working cash balance belonging to each vehicle class was re-calculated. In 1990 and 1991, expenditures exceeded revenues, and monies were withdrawn from the working cash balance. This "supplemental revenue" was allocated to the various vehicle classes in proportion to their net responsibility for its accumulation.

Comparison of Results with Other Studies

Over the four year study period, basic, intermediate, and heavy vehicles were found to be responsible for 64, 10, and 26 percent of the total state highway revenues. These results are consistent with those obtained in other states, as indicated by the comparison presented in Table 17. In reviewing the values reported in Table 17, it is important to note that methodologies and the meanings of parameters may vary between investigations. For example, the basic vehicle in the Oregon study was any vehicle with a weight of 6000 pounds or less (Oregon DOT, 1986). Nevada defined a basic vehicle as any vehicle weighing 6,000 pounds or less in their 1984 study (Nevada DOT, 1984), but they proceeded to change the definition in 1986 to any vehicle weighing 10,000 pounds or less (Nevada DOT, 1986). Naturally, even identical study methodologies yield different results between states, as the motor vehicle tax structures differ between states. Thus, the comparison of revenue allocation presented in Table 17 should only be evaluated from a very general perspective.

Table 17. Comparison of Revenue Allocation with Other Studies.

Study	Percent Allocation		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	64	10	26
Maine, 1989	70	16	14
Vermont, 1991	79	7	21
Nevada, 1984	74	26	
1986	66	34	
1988	59	41	
Oregon, 1986	53	47	
1991	58	42	

EXPENDITURE ALLOCATION

General Remarks

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of the expenditures on the highway system over the 4 year study period. Allocation of the expenditures on specific activities is summarized in Table 18. The specific allocation factors used for each expenditure item for each year of the study period are listed in Table 19. Primary areas of

Table 18. Summary of Expenditure Allocation.

Item	Avg. Annual Expenditures, FY 88-91	Allocation Methodology	% Basic	% Inter.	% Heav
Motor Carrier Services Division Operations	$3,406,492	To non-basic vehicles, based on axle miles (cost to basic vehicles estimated to be less than 1/2 of 1 percent of total)	0	27	73
General Operations	7,496,138	To all vehicles based on VMT	84	7	9
Pre-Construction	5,055,263	To all vehicles based on VMT	84	7	9
Construction	63,098,174	Minimum facility to all vehicles based on VMT, Remainder to all vehicles based on ESAL-M (see also attached activity breakdown)	64	10	26
Maintenance	43,358,455	Primarily VMT to all, pavement costs based on environment vs. traffic related deterioration, environment VMT to all, traffic ESAL-M to all	66	8	26
Bond Interest	9,966,107	Allocated in same fashion as Construction costs	64	10	26
Dept. of Justice	10,384,727	To all vehicles based on VMT	84	7	9
Misc. Expenditures	(663,408)	To all vehicles based on VMT	84	7	9
TOTAL	142,101,946	-	**66**	**9**	**25**

Table 19. Summary of Expenditure Allocation by Study Year.

Expenditure	Allocation, 1988			Allocation, 1989			Allocation, 1990			Allocation, 1991			Over-all Allocation		
	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV
M.C.S. Division Operations	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73
General Operations	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Pre-Construction	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Construction	0.65	0.09	0.26	0.65	0.09	0.26	0.61	0.10	0.29	0.66	0.10	0.24	0.64	0.10	0.26
Maintenance	0.69	0.08	0.22	0.64	0.09	0.27	0.64	0.08	0.28	0.65	0.09	0.26	0.66	0.08	0.26
Bond Interest	0.65	0.09	0.26	0.65	0.09	0.26	0.61	0.10	0.29	0.66	0.10	0.24	0.64	0.10	0.26
Dept. of Justice	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Miscellaneous Expenditures and Adjustments	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Total Expenditures	0.68	0.09	0.23	0.66	0.09	0.25	0.64	0.10	0.26	0.67	0.09	0.24	0.66	0.09	0.25

BV - Basic Vehicle
IV - Intermediate Vehicle
HV - Heavy Vehicle

expenditures include general and Motor Carrier Services Division operations, roadway construction and maintenance, law enforcement, and debt service. Expenditures were allocated to basic, intermediate, and heavy vehicles in accordance with the costs occasioned in providing equivalent service to all users. Different types of cost allocators were used on various expenditure items, depending on the activity involved and the type of vehicle demand being addressed. Activity costs that were independent of the specific vehicles involved were generally allocated based on VMT. Activity costs that were influenced by specific attributes of the vehicles involved were allocated, as possible, based on those attributes.

Allocation of Expenditures on General Operations

The general operating costs of MDT were allocated to all users based on VMT, and over the 4 year study period basic, intermediate, and heavy vehicles were found to be responsible for 84, 7, and 9 percent these expenditures. As the title implies, this category of costs covers expenditures related to the general operation of MDT and includes the costs of the Director's Office, general administration, personnel, accounting, planning, program development, building construction, and building maintenance.

M.C.S. Division Operations

Operation of the Motor Carrier Services Division of MDT was allocated to intermediate and heavy vehicles, only, based on AMT. Following this approach, intermediate and heavy vehicles were found to be responsible for 27 and 73 percent of these expenditures. The Motor Carrier Services Division of MDT is responsible for administering a variety of vehicle related fee programs and legislation enacted by the state of Montana (Motor Carrier Services Division, 1991). Activities of the division include the assessment and collection of gross weight fees, enforcement of vehicle weight and size restrictions (including weigh station operation), issuance of special overweight and oversize permits, etc. Most of the work done by the division is related to larger vehicles; work on matters related to basic vehicles is estimated to account for less than 1/2 percent of division expenditures (Galt, 1992). Thus, Motor Carrier Services division costs were allocated only to intermediate and heavy vehicles. AMT was selected as an appropriate cost allocator, as many fee and enforcement activities were axle, rather than vehicle, related.

Pre-Construction

The costs of preconstruction activities were allocated based on VMT. The specific activities grouped in this category include: engineering administration; project management; right-of-way procurement; and roadway, bridge, and traffic engineering. All these costs were assumed to be independent of the specific vehicle under consideration. Note that in some cost allocation studies, part of the right-of-way costs are allocated based on vehicle width, with the idea that wider vehicles require wider lanes and subsequently wider right-of-ways than basic vehicles (e.g., Nevada, 1984). In this study, however, it was decided that all vehicles share benefits from wide travel lanes, and thus VMT was an appropriate cost allocator.

Construction

Expenditures on highway construction and maintenance amounted to 75 percent of the total monies spent over the study period, and most of these expenditures were for work done on the primary rural system. MDT clearly differentiates between construction and maintenance activity costs for administrative purposes, and this same division in activities was followed in this study. In general, construction was defined as activities that resulted in a long term improvement in the level of service provided by a highway facility. Maintenance tasks were defined as those activities related to simply maintaining the level of service provided by an existing facility over the short term.

Basic, intermediate, and heavy vehicles were allocated 64, 10, and 26 percent of construction costs, respectively, over the study period. To allocate construction expenditures, a cost analysis was performed of all the construction projects let during the study period. Costs obtained from contract documents were regrouped by type of activity rather than individual project cost. The specific activity categories used in this study are listed in Table 20. Annual expenditures on each activity were assigned to basic, intermediate, and heavy vehicles using the allocators listed in Table 20. Note that activity costs were tabulated and allocated independently for each unit of the federal aid highway system. Thus, any differences in expenditure and use patterns on the various units of the federal aid system are accurately represented in these results. The total expenditure on each class of vehicle was calculated by summing the costs allocated to each class for each activity across all systems.

These analyses were performed using "as-bid" prices rather than actual construction costs. For this and other reasons, the sum of the expenditures assigned to each vehicle class nominally differed from the reported total construction costs. Therefore, the results of these analyses were used to calculate cost allocators to be used in assigning the actual construction costs to each vehicle class.

Table 20. Summary of Allocation of Construction Costs.

Activity	Percent of All Costs	Allocator
Contract Administration	9	VMT to all
Grading and Drainage	26	VMT to all
Pavement	51	
New Construction/Major Rehabilitation		Minimum facility cost, VMT to all Remaining cost, ESAL-M to all
Sub-Surface/Base		Minimum facility for basic vehicle, environment, and occasional heavy truck
Sub-Surface/Base, Treatments		
New Pavement		
Overlay		Minimum overlay cost, VMT to all Remaining cost, ESAL-M to all
Surface Prep, Existing Roadway		Minimum facility for basic vehicle, environment, and occasional truck
Overlay		(Surface prep cost, ESAL-M to all)
Seal Coats		VMT to all
Structures	3	
Bridges		New-Basic facility cost, VMT to all Remaining cost, TON-M to all, Basic facility cost, DL/TL * Total Cost Rehab-Non-structural costs, VMT to all Structural cost, TON-M to all Structural cost based on structural related loss of sufficiency rating
Weigh Stations/Scales		VMT to vehicles 10,000 lbs and greater
Roadside	1	VMT to all
Traffic	10	
Guard rails, traffic control, etc.		VMT to all
Traffic Control on Projects		VMT to all

These allocators were calculated as the ratio of the cost assigned to each vehicle class divided by the total assigned costs.

Reviewing Table 20, the costs of many of the construction activities were simply allocated based on VMT. The costs of all such activities were judged to be independent of the characteristics of the specific vehicles that used the highway. Activities related to paving and structures were allocated based on VMT and ESAL-M or AMT, as the effort required to provide these facilities was directly related to the configuration and weight of the vehicles to be served. Each construction activity is briefly described in the following paragraphs with comments, as appropriate, on the attendant cost allocator used. Note that construction engineering costs were prorated across all activities.

Contract Administration: As indicated by the title, this activity consists of the administrative tasks associated with conducting a construction project. This cost was shared between the three classes of vehicles based on VMT.

Grading and Drainage: This category of activities covers construction site work, exclusive of placing the base and the wearing surface (pavement). Major activities in this category of expenditures include (a) surveying, clearing, and grading the roadway, (b) excavating, placing, and backfilling drains and culverts, (c) constructing embankments and retaining walls, and (d) relocating storm drains and water and sewer lines. The costs of all these activities were allocated based on VMT. Once again, in some cost allocation studies, part of the site preparation costs are allocated based on vehicle width, under the premise that wider vehicles require a wider road and right of way. In this study, it was assumed that all vehicles realize advantages from wider roads, and thus costs are unrelated to any variations in width between conventional highway-size vehicles. Consideration was given to allocating some part of culvert costs based on vehicle weight. Discussions with the Hydraulics Division of MDT, however, revealed that culvert selection is rarely dictated by vehicle loads (Goodman, 1992).

Roadway: For new construction and major reconstruction, roadway activities consisted of sub-surface preparation and placement of the base and wearing surface. Part of the cost of these activities was allocated using VMT, while the remainder was allocated using ESAL-M.

Roadways deteriorate due to traffic loads and weathering/aging processes. From a cost allocation perspective

1) fixed costs involved in constructing the roadway should be shared by the various classes of vehicles based on VMT. Such costs, including equipment mobilization and other items, are clearly independent of the specific vehicles involved.

2) costs associated with vehicle related deterioration of the roadway should be allocated based on the physical demand various vehicles place on the roadway. These demands will generally determine the thickness of the base and wearing surface. To design the base and wearing surface, these demands are quantified in terms of total expected ESALs, as previously discussed. (Note that the width of the wearing surface, as it is related to the width of the vehicles being served, has been eliminated from consideration for reasons previously discussed.)

3) costs associated with weathering and aging related deterioration should be allocated based on VMT. These costs can be considered independent of vehicle configuration.

To meet these allocation objectives, roadway costs were divided into two components, (a) the cost of a basic facility with a 20 year design life to resist weathering and aging related deterioration and to carry predominantly basic vehicle traffic and an occasional heavy truck, and (b) the additional cost of providing a facility to carry the complete traffic stream. The cost of the basic facility was allocated to all vehicles using VMT. The additional cost of the full facility to carry the complete traffic stream was allocated based on ESAL-M.

To implement this allocation process, the MDT Materials Bureau designed basic facilities for each district in the state highway system to carry the average basic vehicle traffic observed on each unit of the federal aid system. In designing these basic facilities, the thickness of the running surface was held constant at 1.8 inches (the minimum thickness that presently can be placed) while the base thickness was varied from 4 inches to 18.5 inches in

response to changing subgrade conditions and vehicle loads. These basic facilities are described in detail in Appendix B. To simplify the allocation process, a single basic facility was developed for use across the entire state for each unit of the federal aid system. These facilities were determined by averaging the base thicknesses required in each district weighted by the miles of highway of that type in the district.

The costs of major pavement overlay projects were allocated to the various classes of highway users in a similar fashion as roadway construction and rehabilitation projects. The cost of a basic overlay was allocated to all users based on VMT while the costs of any additional thickness of overlay was allocated based on ESAL-M. While a basic overlay of 1 inch was theoretically adequate in all cases, the minimum thickness of overlay that could be practically placed was 1.8 inches (Stevenson, 1992).

For all construction projects, the estimated cost of the basic facility was subtracted from the reported cost of roadway activities to determine that portion of the costs to be allocated based on ESAL-M. For this purpose, the unit costs of the various basic facilities were estimated in 1991 dollars; unit costs for other years in the study period were estimated assuming a 4 percent inflation rate. If the minimum facility cost was greater than or equal to the reported actual base and wearing surface costs, all costs were allocated based on VMT.

Inherent in this approach to allocating base and wearing surface costs is the fundamental assumption that the primary purpose of the highway system is to serve basic vehicles, and that the extra costs of providing service to intermediate and heavy vehicles due to their increased demand on the system are added to the cost of providing service for basic vehicles. This assumption is somewhat supported by the traffic data, in that basic vehicles account for approximately 84 percent of system use based on VMT. While the increased demand by intermediate and heavy vehicles is significant (these vehicles account for approximately 88 percent of the ESAL-M), this demand can be met with a proportionally smaller increase than might be expected in the thickness of the base and wearing surface (the relationship between thickness and ESAL capacity is non-linear). Thus, if highway cost is expressed in terms of dollars per ESAL of demand, the unit cost of the added thickness of roadway to meet the demands of intermediate and heavy vehicles is lower than the unit cost of the initial thickness required to meet the demands of basic vehicles.

The approach to allocating roadway costs used in this study, described as a modified incremental approach, combines elements of two cost allocation methods commonly used in

studies of this type, namely, the Federal and Incremental Methods (Urban Institute, 1990; FHWA, 1984). The approach is patterned after that used by the state of Nevada in their cost allocation studies (Nevada DOT, 1984, 1986, 1988). With respect to roadway cost allocation, the Federal and Incremental Methods differ in the procedure and philosophy used to allocate the cost of vehicle related deterioration of the roadway. In the Federal approach, a basic facility is defined as the minimum facility that would be built independent of the level of traffic to be served. Such a facility could be considered as the basic facility required to resist weathering and aging deterioration over the design life of the pavement. The cost of such a facility is commonly shared by all users (VMT allocated). The additional cost of a facility designed to carry the expected traffic loads is shared among all users based on the level of demand they will place on the highway (ESAL-M allocated). Following this approach, the unit cost per ESAL of demand is the same for all users and all ESALs. Providing highway service to intermediate and heavy vehicles is thus treated as an integral part of the purpose of the highway system, instead of an add-on function.

Following the Incremental Method, highway costs and capacity are viewed incrementally. Users pay for all increments in system capacity required to meet their particular demands. In the case of roadway costs, all vehicles share in the cost of the first increment in capacity (the cost of a basic facility), while successive increments are shared only by the heavier vehicles that occasion them. The final increment of capacity is only paid for by the vehicles placing the highest demand on the system. Note that the unit costs of successive increments of service decrease (due to the non-linear relationship between the capacity of added increments of roadway thickness and the cost to provide them). The allocation method used in this study considers a basic facility and a single increment in capacity. All vehicles share the increment in capacity based on ESAL-M.

A simple illustration of roadway cost allocation using the three allocation methods discussed above is presented in Table 21. Some cost allocation studies present alternate solutions using the Federal and Incremental Methods. It is generally acknowledged that the Federal Method shifts more of the roadway costs from basic to heavy vehicles compared to the incremental methods. The costs allocated to basic vehicles are similar using the Incremental and modified incremental approaches. The modified incremental approach, however, results in the allocation of more of the non-basic vehicle costs to heavier vehicles compared to the results obtained using the Incremental Method.

Table 21. Illustration of Different Methods for Allocating Roadway Costs.

(a) Assumed Vehicle Use

Vehicle Class	System Use (Annually)		
	Vehicle Trips	Tons	ESALs
Basic	217,000	416,424	217
Intermediate	18,791	144,917	4,182
Heavy	23,123	641,998	34,820
All	258,914	1,203,339	39,219

(b) Characteristics of the Roadway

Roadway Being Considered	Required Base Thickness	Wearing Surface	Estimated Cost, 32 ft Width, 1 mile
Minimum Facility, Independent of Vehicle Use	3.5	1.8	65,055
Basic Facility, Service to Basic Vehicles Only	8.0	1.8	94,389
Intermediate Facility, Service to Basic and Intermediate Vehicles	23.0	1.8	192,167
Full Facility, Service to All Vehicles	30.0	1.8	237,797

(c) Allocation of Cost

Vehicle Class	Cost Responsibility in Thousands of Dollars								
	Modified Incremental Method			Federal Method			Incremental Method		
	VMT	ESAL	Total	VMT	ESAL	Total	VMT	TMT	Total
Basic	79.1	0.8	79.9	54.5	1.0	55.5	79.1	0.0	79.1
Inter.	6.9	15.3	22.2	4.7	18.4	23.1	6.9	18.0	24.9
Heavy	8.4	127.3	135.7	5.8	153.4	159.2	8.4	125.3	133.7
All	94.4	143.4	237.8	65.0	172.8	237.8	94.4	143.3	237.8

Structures: Bridge projects were divided into two categories, namely, construction (new and replacement) and rehabilitation. Bridge construction costs were allocated to the various vehicle classes based on VMT and TMT. Rehabilitation costs were allocated based on VMT. The intent of the allocation process was to assign (a) common costs (costs independent of the specific vehicles being served) based on VMT and (b) costs incurred to carry specific vehicle loads based on TMT.

Bridges are designed to carry a variety of loads, including their self weight (dead load), the weight of vehicles on the bridge (live load), any enhancement of vehicle loads due to dynamic effects (impact load), wind loads, and loads induced by earthquakes. Often, the over-all design of a bridge is controlled by the magnitudes of the dead load and the live and impact loads. The magnitudes of the live and impact loads are directly related to the weight of the vehicles the bridge is designed to serve. Thus, the costs associated with carrying live and impact loads were allocated based on vehicle weight (i.e., using TMT). All other costs were shared by all vehicle classes based on VMT.

That part of the bridge construction costs to be allocated based on VMT was calculated by multiplying the dead load to total load ratio for the bridge by the total construction cost. The remaining cost was presumed to be live and impact load related, and this cost was allocated based on TMT. This approach was used as an alternative to the costly process of designing minimum bridge facilities (to carry dead load only) to determine that part of bridge construction costs to be allocated based on VMT. This approach was reportedly first used by the state of Nevada in their cost allocation study (Nevada, 1984).

The Bridge Bureau at MDT determined the dead load to total load ratios used in this study by reviewing the design documents from every bridge constructed during the study period. Following the approach successfully used by the state of Nevada (Nevada DOT, 1984), dead load to total load ratios were determined for each bridge independently for the substructure and superstructure, which were then averaged to obtain a composite ratio for the bridge. For each major unit of the federal aid system, the dead load to total load ratios were weighted by the associated bridge lengths to obtain an average ratio to be used across that unit of the system. These ratios are presented in Table 22.

Bridge rehabilitation costs were allocated to the vehicle classes based on VMT. Structural condition was the only cause for bridge rehabilitation judged to be directly related to a specific vehicle attribute (weight). The structural adequacy of fifty-eight of the 61

Table 22. Dead Load to Total Load Ratios for Bridges.

System	Dead Load to Total Load Ratio
Interstate	*0.85
Primary	0.75
Secondary	0.77
Urban	**0.76
Off-System	0.61

Source: Bridge Bureau, MDT (Murphy, 1992)
* Based on a single bridge
** Based on two bridges

bridges rehabilitated during the study period was the same before and after rehabilitation (Murphy, 1992).

Roadside: Activities in this category are primarily "landscaping" related, e.g., sprinkler systems, sodding, seeding, wetlands development, etc. Costs of these activities were VMT allocated.

Traffic: Activities in this category are related to controlling and directing vehicles, and include placing signs, guardrails, signals, etc. Costs of these activities were allocated based on VMT.

Maintenance

Basic, intermediate, and heavy vehicles were allocated 68, 8, and 26 percent, respectively, of the maintenance expenditures on the highway system. These costs were primarily allocated using VMT and ESAL-M, based on the specific tasks being considered. The categories of maintenance activities used in this study are listed in Table 23. Annual expenditures on each type of activity were obtained by analyzing accounting information provided by the Maintenance and Equipment Bureau of MDT. The expenditures on each activity were assigned to the various vehicle classes using the allocators indicated in Table 23. Activity costs were tabulated and allocated independently on each of the major units of the federal aid system.

Table 23. Summary of Allocation of Maintenance Costs.

Activity	Percent of All Costs	Allocator
Roadway	25	Pavement related activities in this category Environmental, VMT to all Traffic related, ESAL-M to all (Split, environmental vs. traffic 20/80 interstate, 40/60 for all other systems)
Roadside	5	VMT to all
Drainage	2	VMT to all
Bridges	1	VMT to all
Facilities	7	VMT to all
Traffic Safety	11	VMT to all
Winter Maintenance	17	VMT to all, except sanding and deicing by AMT
Materials Production/Handling/Stockpiling	19	Cost to be split by environmental vs. traffic factor as for pavement activities above
Equipment/Supervision/Overhead	13	VMT to all

The following paragraphs include a brief description of the activities included in each maintenance category and a discussion, as appropriate, of the selected allocation process.

Roadway: Maintenance activities on the roadway primarily consisted of patching and sealing the wearing surface and the placement of thin overlays. Deterioration of seal coats was judged to be related to the number of axle passages over the roadway, and these costs were allocated to all vehicles based on AMT. The costs of patching and overlays were divided into two categories, (a) expenditures caused by traffic related deterioration of the roadway and (b) costs occasioned by weathering and aging related deterioration of the roadway. The costs of traffic related deterioration were allocated based on the demand specific vehicles placed on the roadway as measured in ESALs. The costs associated with weathering and aging related deterioration of the roadway were allocated based on VMT.

The basic division of roadway costs into traffic and weathering/aging related components was determined by estimating the underlying amount of deterioration attributable to each cause. Surveys conducted in other cost allocation studies and guides (Oregon DOT, 1986; Urban Institute, 1990) found that the relative amount of pavement damage assigned to traffic and allocated based on ESAL-M ranged from 54 to 98 percent (see Table 24). Note that many of these estimates were based on expert opinion, rather than rigorous tests. A general consensus does exist that the relative amount of traffic versus weathering/aging damage is influenced by specific climatic conditions, type of pavement, and the volume and type of traffic. Generally, as the volume of traffic (e.g., expressed in ESALs per day) increases, the proportion of damage attributable to environmental factors decreases.

Table 24. Weathering/Aging and Traffic Related Deterioration of Highways

Study	Percent of Pavement Maintenance Costs Allocated Based on ESAL-M
Indiana (1984)	
Northern	66-87
Southern	70-98
Iowa (1983)	
Interstate	90
Surfaced	80
Unsurfaced	50
Maryland (1982)	75
Nevada (1984)	75
Oregon (1980)	90
Vermont (1990)	73
Virginia (1980)	
Interstate	77
Primary	66
Secondary	54

Source: Surveys of maintenance cost allocation given in: Urban Institute (1990), Oregon DOT (1986)

After a review of the various factors presented in Table 24, traffic was assigned responsibility for 80 percent of the roadway deterioration on the interstate system; weathering and aging, 20 percent. On all other systems, traffic was assigned responsibility for 60 percent of the roadway deterioration; weathering and aging, 40 percent. The volume of traffic on the interstate (measured in ESALs/day) is over five times greater than that on any other unit of the federal aid system. Thus, traffic related damage was assessed a higher percentage of the total roadway damage on the interstate versus other systems. Traffic on the other units of the highway system was judged to be generally less than the traffic on comparable highways in all other states included in Table 24, and therefore traffic was only assigned responsibility for 60 percent of the observed pavement damage on these highways.

Roadside: Roadside activities, allocated based on VMT, consisted of mowing, brush and tree cutting, litter pickup, fence and gate repair, etc.

Drainage: This category of activities included cleaning, repairing, and replacing drainage facilities such as culverts and ditches. The costs of these activities were allocated based on VMT.

Bridges: Bridge maintenance costs were allocated based on VMT. A discussion with the maintenance personnel indicated that only minor work was done on bridges as a maintenance activity. All major work that significantly impacted functional capacity was done as a construction activity.

Facilities: Work on rest area and maintenance facilities was included in this activity category. The costs of these activities were allocated based on VMT.

Traffic Safety: This category of activity consists of the repair and replacement of signs, signals, lighting, guardrails, etc. The costs of these activities were allocated based on VMT.

Winter Maintenance: Winter maintenance costs included the costs associated with snow removal, sanding, de-icing, etc. These costs were shared between all users based on VMT, with the exception of sanding and deicing costs, which were allocated based on AMT.

Equipment/Supervision/Overhead: Costs of equipment maintenance, administration, training, and other miscellaneous activities were included in this activity category. These costs were allocated based on VMT.

Bond Principal and Interest

Expenditures related to the $97,000,000 in principal raised through bond sales in 1987 are included in two entries in the cash flow sheet. Revenue raised from the bond sales was to be used in construction projects; thus some of the indicated construction expenditures were bond funded. Additionally, repayment of the bond principal, with interest, is directly included as an entry in the expenditure summary. From a cost responsibility perspective, expenditure of the principal should only be allocated to the various classes of users once, either as a construction expenditure or as debt retirement (otherwise, more money is being allocated than was actually collected). The decision was made to consider the costs of bond funded construction in the allocation process and omit bond principal repayment. Interest payments on the bond proceeds, however, were assigned to the various vehicle classes using the construction cost allocators, consistent with the manner in which the principal was spent. Note that over the four year study period, only interest payments were made on the bond issue, none of the principal was repaid.

Department of Justice

The State Highway Patrol, under the auspices of the Department of Justice, is funded with highway revenues. Expenditures for the highway patrol were shared between the three vehicle classes based on VMT.

Miscellaneous Expenditures

Miscellaneous expenditures included accounting adjustments and nominal payments to the Department of Fish, Wildlife, and Parks ($29,735 over the entire study period) for road work.

Comparison of Results with Other Studies

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of the total expenditures on the highway system over the 4 year study period. These results are compared with the results obtained in other studies in Table 25. The results from this study fall within the results obtained in those studies. In evaluating the comparison presented in Table 25, it is

important to note that significant variations do exist in the highway system requirements and associated highway expenditures between states, and that the methodology used in allocating these expenditures may vary between studies.

Table 25. Comparison of Expenditure Allocation with Other Studies.

Study	Percent Allocation		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	66	9	24
Maine, 1989	70	17	13
Vermont, 1991	79	6	15
Nevada, 1984	64	36	
1986	64	36	
1988	59	41	
Oregon, 1986	59	41	
1991	62	38	

COMPARISON, REVENUE AND EXPENDITURES

General Remarks

One useful method to report the results of a cost allocation study is in the form of equity ratios. An equity ratio is defined as the ratio of the percentage of revenue allocated to a vehicle class divided by the corresponding percentage of allocated expenditures. An equity ratio greater than one indicates that vehicle class is overpaying for its use of the highway system compared to other vehicle classes; correspondingly, an equity ratio less than one indicates relative underpayment by a vehicle class for its use of the highway system. It is important to recognize that equity ratios only indicate relative overpayment or underpayment by various highway users, not absolute underpayment or overpayment for the highway system. In the last two years of the study period, for example, highway expenditures exceeded revenues, indicating all users may possibly be underpaying the state for the highway system.

While the principal intent of this part of this investigation was to determine the relative equity of the existing payments made by various classes of vehicles for their use of the highway system, general approaches were explored for remedying the inequities in these payments that were identified herein. The analyses performed on past revenues and expenditures in support of the basic cost allocation study were used to evaluate the influence of changes in revenues and expenditures on the equity situation. Note that only inequities between the classes of vehicles considered in the cost allocation study (basic, intermediate, and heavy vehicles) could be addressed in these analyses. Additional cost allocation analyses will have to be performed to identify relative equity differences between vehicles within each class, before more refined changes in the revenue and expenditure situation can be evaluated (such analyses are presently underway). Further note that possible changes in highway use precipitated by changes in fees and charges to use the highway system were not considered in assessing the impact of such changes on the equity situation.

Equity Ratios

The average equity ratios determined in this investigation over the 4 year study period for basic, intermediate, and heavy vehicles were 0.96, 1.11, and 1.07, respectively. Thus, basic vehicles were found to be relatively underpaying for their use of the highway system, while intermediate and heavy vehicles were found to be overpaying for their use of the highway system.

The equity ratios calculated for the 3 classes of vehicles for each year of the study period are presented in Table 26. In each year of the study, basic vehicles had the lowest equity ratio; intermediate vehicles, the highest equity ratio. The equity ratio for basic vehicles steadily increased for the first three years of the study period, reaching a peak of 0.99 in 1990, and then declined to 0.97 in 1991 (the last year included in the study). The equity ratios for intermediate and heavy vehicles steadily decreased for the first three years of the study period, dropping in 1990 to 1.06 and 1.00, respectively. This trend reversed between 1990 and 1991, as the equity ratios for intermediate and heavy vehicles increased to 1.10 and 1.05, respectively.

Based on the results presented in Table 26, it is difficult to exactly predict future equity ratios. The reversal in the steady trend in the equity ratios observed for all vehicle classes between 1990 and 1991 cannot be reliably predicted to continue in 1992 and subsequent years, based on the limited data available. None-the-less, it can be predicted that radical changes in the magnitudes of the equity ratios over the next few years are unlikely, in that the changes in the ratios between consecutive years of the study period were a maximum of 8 percent and averaged only 5 percent. Furthermore, the relative magnitudes of the equity ratios of the various vehicle classes can be expected to remain the same in the future, that is, basic vehicles can be expected to continue to have the lowest equity ratios; intermediate vehicles, the highest equity ratios.

Comparison of Results with Other Studies

The equity ratios obtained in this study are consistent with those obtained in other studies, as indicated by the limited survey of such results presented in Table 27. The results presented in Table 27 indicate the wide range of equity situations that exist in various states between classes of vehicles. Once again, the information presented in Table 27 should be viewed only from a general perspective, in that motor vehicle tax revenues and highway expenditures vary between states, and the manner in which these revenues and expenditures were analyzed may vary between studies.

Equity Adjustments

The analysis program developed to allocate historical revenue and expenditure data was used to evaluate the effect of changes in the revenue/expenditure structure on the equity ratios for the vehicle classes. Tentative efforts were made to change the structure to improve relative equity between the vehicle classes. The simplest and most direct improvement was obtained by increasing

Table 26. Comparisons, Allocated Revenue and Expenditures.

Fiscal Year	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
1988			
Revenue, Percent	63.5	10.5	26.0
Expenditures, Percent	68.2	9.0	22.8
Equity Ratio	0.93	1.16	1.14
1989			
Revenue, Percent	62.4	10.5	27.1
Expenditures, Percent	65.8	9.2	25.0
Equity Ratio	0.95	1.14	1.09
1990			
Revenue, Percent	63.4	10.3	26.3
Expenditures, Percent	63.9	9.7	26.4
Equity Ratio	0.99	1.06	1.00
1991			
Revenue, Percent	64.8	10.3	24.9
Expenditures, Percent	66.9	9.4	23.8
Equity Ratio	0.97	1.10	1.05
Over All Years			
Revenue, Percent	**63.5**	**10.4**	**26.1**
Expenditures, Percent	**66.2**	**9.3**	**24.5**
Equity Ratio	**0.96**	**1.11**	**1.07**

the new vehicle sales tax by 400 percent. Equity ratios close to 1.0 were generated for all three classes of vehicles by this action. Alternatively, increasing the gasoline tax 22.5 percent, from $0.20 to $0.245 per gallon, improved the equity situation between basic and heavy vehicles. This change resulted in equity ratios of 0.986 and 0.982 for basic and heavy vehicles, respectively. This change, however, had a negative impact on the equity ratio for intermediate vehicles, increasing this ratio from 1.11 to 1.14. This situation was improved by reallocating the gross weight fees paid by the various vehicle classes to reduce the responsibility of intermediate vehicles for such payments.

Table 27. Comparison of Equity Ratios with Other Studies.

Study	Equity Ratio		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	0.96	1.11	1.07
Maine, 1989	0.99	0.96	1.09
Vermont, 1991	1.02	1.11	0.92
Wyoming, 1981*	1.00	1.26	1.20
Nevada, 1984	1.11	0.74	
1986	1.03	0.95	
1988	1.00	1.00	
Oregon, 1986	0.90	1.15	
1991	0.94	1.11	

* values estimated from information presented in cost allocation study and normalized to 1.00 for basic vehicles

Increasing basic vehicle contributions was judged to be a prudent approach to address the cost inequities identified in this study. The major inequity revealed by the study was the relative underpayment of basic vehicles and overpayment of intermediate and heavy vehicles for their use of the highway system. Approaches considered to alleviate this inequity consisted of adjusting the relative revenues and expenditures associated with each vehicle class. Highway expenditures and their allocation to various users are generally fixed by the physical requirements of providing equivalent service to all users. Thus, highway revenues were selected for adjustment in addressing inequities in user payments. To alleviate the particular inequities in user payments identified in this study, more revenue needed to be allocated to basic vehicles relative to intermediate and heavy vehicles. This reallocation could have been accomplished by increasing basic vehicle contributions, decreasing intermediate and heavy vehicle contributions, or both. Increasing revenue was deemed appropriate, in that total revenue was less than total expenditures during the last two years of the study period.

Sources of revenue dominated by basic vehicle contributions (followed by heavy vehicle contributions) were initially considered in the equity adjustment process. Reviewing Table 6, such sources were found to consist of the new vehicle sales tax, contributions from the Coal Tax Trust Fund, bond proceeds and earnings, and miscellaneous accounts receivable. Of these various revenue

sources, the new vehicle sales tax was selected as possibly most appropriate for modification. The revenue generated by this tax, however, was sufficiently low that a major change in the tax rate was necessary to significantly impact the overall equity ratios. A uniform 400 percent increase in the new vehicle sales tax resulted in equity ratios for all 3 vehicle classes between 0.98 and 1.01.

Alternatively, revenue sources were searched for that consisted primarily of basic vehicle contributions and that constituted a significant portion of the total highway revenues collected. The gasoline tax fit these parameters. Increasing the gasoline tax by only 22.5 percent resulted in equity ratios of 0.986 and 0.982 for basic and heavy vehicles, respectively. Unfortunately, intermediate vehicles paid substantial gasoline taxes, and thus their overall equity ratio increased from 1.11 to 1.14 in response to this gas tax increase. Attempts were made to offset this increase in the intermediate vehicle equity ratio by reallocating other revenue. A reduction of intermediate vehicle gross weight fees was considered with an attendant increase in basic vehicle and heavy vehicle fees. Reassigning all the gross weight fees paid by intermediate vehicles to basic and heavy vehicles still resulted in an equity ratio for intermediate vehicles of 1.03. Alternatively, gross weight fees for basic and heavy vehicles could simply have been raised. Increasing the diesel fuel tax improved the equity situation between intermediate and heavy vehicles, but this approach further reduced the equity ratio for basic vehicles.

Eventually, the decision was made to postpone further attempts to improve the equity situation between vehicle classes until a more comprehensive review of the motor vehicle tax structure could be completed.

SUMMARY AND CONCLUSIONS

Summary and Conclusions

The results of this cost allocation study, conducted on state revenue and expenditures on the highway system, indicate that basic vehicles are relatively underpaying for their use of the system while intermediate and heavy vehicles are relatively overpaying for their use of the system. Equity ratios were determined for each vehicle class by dividing the percentage of highway revenue assignable to each vehicle class by the associated expenditures involved in providing that class of vehicles with highway service. The equity ratios determined herein for a four year study period ending in 1991 were 0.96, 1.11, and 1.07, respectively, for basic, intermediate, and heavy vehicles. Approaches to improving the equity situation between vehicle classes were tentatively investigated. These approaches included (a) increasing the new vehicle sales tax (by 400 percent) or (b) increasing the gasoline tax (by 22.5 percent) in conjunction with altering other fees. Specific recommendations for changing the motor vehicle fee structure were deferred until a more thorough review of the tax structure is completed.

The equity ratios presented above were determined by analyzing revenue and expenditure data for the state highway system over the period from 1988 to 1991. The purpose of this analysis was to allocate all revenues and expenditures to the various classes of vehicles that use the highway system. Only state revenues and expenditures were considered. Fees paid to the federal government and federal expenditures on the highway system were not considered in the study. Revenues and expenditures were assigned to 3 broad classes of vehicles, namely, basic vehicles (gross weight of less than 10,000 pounds), intermediate vehicles (2 axle single units with gross weights greater than or equal to 10,000 pounds but less than 26,000 pounds and busses) and heavy vehicles (3 or more axle single units and all combinations).

This study determined that basic, intermediate, and heavy vehicles were responsible for 64, 10, and 26 percent of highway revenues. These revenues primarily consisted of fuel taxes, new vehicle sales taxes, gross weight fees, bond proceeds and interest, and proceeds from the Coal Tax Trust Fund. Revenue directly derived from users was allocated to the various vehicle classes in the manner in which it was collected. Revenue from general sources (e.g., bond proceeds and interest) was shared between vehicle classes based on their relative use of the highway system, consistent with the philosophy that the intent of such funding was to provide equal benefit and service to all users.

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of highway expenditures, respectively. These expenditures primarily consisted of the general operation of the Department of Transportation, operation of the Motor Carrier Services Division, and highway construction and maintenance. Different methods were used to allocate these costs based on the specific tasks under consideration. The costs of activities that were independent of the specific vehicles being served were allocated based on the relative miles travelled by each class of vehicles. Costs that were influenced by attributes of the specific vehicles being served were allocated, as possible, based on that attribute. Roadway (base and wearing surface) construction and maintenance costs were the primary expenditures on the highway system. Roadway construction costs were allocated using a modified incremental approach in which all vehicles shared the cost of a facility to provide service for basic vehicles based on vehicle miles travelled. The remaining cost of the full facility was allocated based on ESAL miles travelled. Pavement maintenance costs were split between costs related to traffic damage and costs related to weathering and aging damage. Traffic related costs were allocated to all users based on ESAL miles travelled; weathering/aging related costs, based on vehicle miles travelled.

Recommendations for Future Studies

The cost allocation study should be updated at regular intervals to reflect changes in traffic patterns, funding levels, and expenditure philosophies. Oregon and Nevada, for example, update their studies every 2 years. The results of the Nevada studies are used by the state legislature in evaluating revisions to the motor vehicle tax structure. Revision of the Montana study will be appropriate within two years due to,

(a) the reorganization of the federal aid highway system under the new Surface Transportation Act and the attendant change in federal cost share ratios and total federal dollars available for highway construction.

(b) the emerging fiscal trend of state highway expenditures exceeding annual revenue. Over the four year study period, the cash flow balance at the end of each year steadily eroded from a surplus of $15,005,460 in 1988 to a deficit of $39,238,516 in 1991. This situation will force a change to occur in either the motor vehicle revenue structure or the level of expenditures on the highway system.

In preparing an update to the study, the opportunity may exist to expand the depth of the investigation and to refine the methodology employed. It would be informative to perform additional

analyses using alternate allocation strategies for those revenue and expenditure items which can be reasonably allocated in several ways. Construction expenditures on the base and wearing surface of the roadway are an example of such an item. These expenditures have been variously allocated in state cost studies using the federal, incremental, and modified incremental approaches (as previously discussed). The influence of the approach selected for allocation of these costs on the final results of the study has been significant in some investigations. Additional research should also be done on the sensitivity of the study results to specific assumptions made in the allocation process. Such information would reveal the areas that should first receive attention in any future efforts to improve the study results. One such assumption, for example, is the split assumed between traffic and weathering/aging related deterioration of the roadway wearing surface that is used in allocating maintenance costs. It may be possible to more definitively establish this value than was done in this study by rigorously reviewing the available information on the subject, conducting a survey of maintenance experts around Montana, etc. Such efforts would only be justified, however, if this value has a significant influence on the study results.

The cost allocation analyses conducted herein can possibly be modified to better predict the future equity situation than is presently being done. MDT generates a cash flow table of projected revenue and expenditures similar to the historical cash flow table upon which this study is based. Assuming that highway use and needs are relatively stable, the allocators developed in this study can be applied to future revenues and expenditures to obtain an approximate indication of the future equity situation. Such information might be useful in evaluating any contemplated changes to the motor vehicle tax structure.

The results of this and future cost allocation studies are only as reliable as the data upon which they are based. Generally, excellent data was available from MDT to support this study. Specific changes that would facilitate and improve future studies include:

1) collection of more traffic data on the secondary system (although expenditures on this system represent only a small fraction of the total fiscal situation) and
2) better identification of the specific sources of new vehicle sales tax revenue and gross vehicle weight fees.

The latter change is essential, if the cost allocation study is to address equity between vehicle types within each major user class. The addition of cost allocation identifiers to the accounting systems used to track construction and maintenance costs would facilitate the processing of this information. The required data processing, however, can be reasonably accomplished using the present systems.

With-in the framework of the existing study, some of the revenue and expenditure items presently assigned in a lump sum fashion could possibly be broken down in future studies into their constituent elements and allocated at that level (e.g., miscellaneous fees collected by the M.C.S. division and miscellaneous accounts receivable). While individual refinements of this kind will only have a small impact on the study results, their net effect could be significant.

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APPENDIX A

Cash Flow Table, MDT, FY 1987 - 1991

This appendix contains the original cashflow table provided by the Financial Management Bureau of the Montana Department of Transportation listing the highway system expenditures and revenues upon with this cost allocation study is based.

MONTANA DEPARTMENT OF TRANSPORTATION
ACTUAL CASH FLOW
FY '87 - FY '91

	FY '87	FY '88	FY '89	FY '90	FY '91
BEGINNING WORKING CASH BALANCE	$45,286,748	$126,618,131	$140,748,187	$145,538,177	$129,627,153
REVENUE					
G.V.W.	22,263,806	23,967,756	25,280,566	26,739,312	25,177,590
Gas Tax	66,608,309	79,675,077	82,691,513	82,297,751	81,146,066
Diesel Tax	17,541,396	21,185,520	22,708,492	23,821,548	22,797,863
Accounts Receivable	1,229,343	2,213,013	2,107,333	4,978,078	3,784,789
Coal Tax	5,940,016	10,156,597	7,027,869	8,144,464	6,054,941
Bond Interest Earnings	1,216,004	9,053,452	6,200,687	3,925,575	725,549
Bond Proceeds	97,657,126	26,701	0	0	0
Stores	10,065,499	11,375,963	12,095,355	13,605,350	12,950,817
OTHER:					
Dept. of Justice	0	0	0	20,366	33,363
ACI Reimbursement	10,935,298	7,489,996	0	0	0
Prior Year Revenue Adj.	417,229	(118,859)	(31,372)	(86,319)	(144,359)
TOTAL REVENUE	$233,874,026	$165,025,216	$158,080,443	$163,446,125	$152,526,619
AVAILABLE WORKING CASH	$279,160,774	$291,643,347	$298,828,630	$308,984,302	$282,153,772
EXPENDITURES					
G.V.W.	3,255,720	3,392,515	3,377,012	3,370,452	3,485,987
General Operations	4,627,146	5,055,256	4,773,934	6,075,639	6,256,817
Construction	17,339,253	25,927,493	8,316,283	12,972,429	33,334,624
Maintenance	38,165,557	40,968,264	42,121,180	44,480,936	45,863,441
Preconstruction	6,096,939	3,847,939	4,607,207	5,028,133	6,737,771
Equipment	2,247,850	1,930,659	800,000	0	0
Headquarters Building	224,067	596,085	549,402	525,821	528,899
A. & E.	464,646	1,143,947	716,699	457,942	573,450
Local Government	14,144,825	14,146,250	14,146,250	14,146,248	14,146,250
Bond Principal & Interest	15,069,700	10,041,082	10,041,083	10,041,083	9,741,178
Reconstruction Trust	30,632,131	21,072,047	25,952,555	41,025,782	48,379,609
Motor Fuels	0	0	0	0	713,293
Dept. of Revenue	737,870	783,472	737,832	696,250	0
Dept. of Justice	9,200,816	9,708,600	9,957,471	10,885,348	10,987,488
Stores	10,464,022	12,244,376	11,910,013	13,209,039	13,288,393
Bond 4 ACI Const.	0	0	1,741,119	0	0
Bond 4 SS Const.	0	0	17,326,907	16,343,848	0
Dept. of Fish Wildlife & Parks	0	0	0	0	29,735
Entity Adjustment	(465,944)	(304,359)	(3,638,270)	83,756	(126,718)
Prior Year Adjustment	338,045	341,534	(146,224)	14,443	(1,838,376)
TOTAL EXPENDITURES	$152,542,643	$150,895,160	$153,290,453	$179,357,149	$192,101,841
ENDING WORKING CASH BALANCE	$126,618,131	$140,748,187	$145,538,177	$129,627,153	$90,051,931

APPENDIX B

Basic Facility Definitions, Base and Wearing Surface

Included in this appendix are the basic facility designs used in allocating highway construction costs for the base and wearing surface.

Montana Department of Transportation
Helena, Montana 59620

Memorandum

To: Bill Cloud, Chief
Passenger Transportation Bureau

Thru: Kenneth H. Neumiller, Supervisor
Materials Services Section

From: James R. Stevenson, Manager
Pavement Analysis Unit
Materials Bureau

Date: April 3, 1992

Subject: Minimum Facility Design

As per Jerry Stephens' request, please find a copy of the new Construction and Overlay Minimum Facility Designs attached. Included is a list of all assumptions needed for the mechanistic design and cost analysis.

JS:D:MT:40.dr

Attachment

cc: Ken Neumiller
James Stevenson

NEW CONSTRUCTION MINIMUM FACILIT DESIGN

ROUTE TYPE	THICKNESS	REGION 1	REGION 2	REGION 3	REGION 4	RE
SECONDAR	PMS	1.8	1.8	1.8	1.8	
	CBC	4.0	4.0	5.0	7.5	
	COST MI	51.500	61.500	68.000	85.000	57
PRIMAR. RURAL	PMS	1.8	1.8	1.8	1.8	
	CBC	5.0	6.0	6.	11.0	
	COST.MI	77.500	85.500	110.000	125.000	1
INTERSTATE RURAL	PMS	1.8	1.8	1.8	1.8	
	CBC	7.0	8.5	11.5	15.5	1
	COST/MI	214.000	221.000	292.000	365.000	3
URBAN	PMS	1.8	1.8	1.8	1.8	
	CBC	8.5	10.5	13.5	18.5	1
	COST/MI	133.000	150.000	181.500	234.5000	178
INTERSTATE URBAN	PMS	1.8	1.8	1.8	1.8	
	CBC	10.0	12.0	15.0	20.5	1
	COSTMI	265.000	301.000	355,500	461.000	33
PRIMARY URBAN	PMS	1.8	1.8	1.8	1.8	
	CBC	11.5	13.5	17.5	24.0	1
	COST.MI	131.000	149.000	187.500	257.500	19

MINIMUM FACILITY OVERLAY DESIGN

THE OVERLAY FOR THE MINIMUM FACILITY IN ALL REGIONS AND CLASSIFICATIONS WOULD BE LESS THAN 1 INCH . HOWEVER STANDARD CONSTRUCTION PRACTICES WOULD REQUIRE 1.8 INCHES

MINIMUM FACILITY DESIGN ASSUMPTIONS

1' ANNUAL ESALs	NEW CONSTRUCTION	OVERLA
SECONDARY	70	10
PRIMARY RURAL	217	29
INTERSTATE RURAL	558	9
URBAN	981	177
INTERSTATE URBAN	1278	2
PRIMARY URBAN	1901	29

PLANT MIX MODULUS (FOR ALL REGIONS - 350,000

BASE GRAVEL MODULUS - REGION 1 - 28000
REGION 2 - 23000
REGION 3 - 25000
REGION 4 - 22000
REGION 5 - 25000

SUBGRADE MODULUS REGION 1 - 12000
REGION 2 - 10000
REGION 3 - 8000
REGION 4 - 6500
REGION 5 - 7500

DESIGNED USING THE MICHPAVE ANALYSIS PROGRAM (LINEAR ANALYSIS)

3 LAYER ANALYSIS

10000 LBS MAXIMUM WHEEL LOAD

100 PSI TIRE PRESSURE

AVERAGE ANNUAL TEMPERATURE - 50 (FAHRENHEIT)

PERCENT AIR VOIDS IN PMS - 5 %

KINEMATIC VISCOSITY (85 - 100) 270

POISSON'S RATIO - PLANT MIX - .40
BASE GRAVEL - .42
SUBGRADE - .45

DENSITY - PLANT MIX - 150
BASE GRAVEL - 125
SUBGRADE - 115

Mo - PLANT MIX - 2.5
BASE GRAVEL - 1.5
SUBGRADE - 0.8

REGIONS BASED ON THE 5 DISTRICTS

COST ASSUMPTIONS - PLANT MIX - $45/cu yd
BASE GRAVEL - $12.50/cu yd

PAVEMENT WIDTH - SECONDARY - 28 FT
PRIMARY RURAL - 32 FT
INTERSTATE RURAL - 76 FT
URBAN - 40 FT
INTERSTATE URBAN - 76 FT
PRIMARY URBAN - 32 FT

NOTE: UNLESS NOTED
REGIONAL DISTRICTS
FROM S.T. [illegible]
ON 4/2/[illegible]

FINAL
REPORT

Ice Blue Cover

5- Front
63- Text
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COST ALLOCATION STUDY

for the

MONTANA STATE HIGHWAY SYSTEM

Prepared by

Jerry Stephens
Department of Civil and Agricultural Engineering
Montana State University
Bozeman, Montana

and

Tim Barth and William Cloud
Montana Department of Transportation
Helena, Montana

Prepared for
STATE OF MONTANA
DEPARTMENT OF HIGHWAYS
RESEARCH PROGRAM
in cooperation with the
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

July 1992

COST ALLOCATION STUDY

for the

MONTANA STATE HIGHWAY SYSTEM

July 1992

CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

The objective of this project was to review motor vehicle related revenues and highway expenditures in the state of Montana and suggest revisions to the revenue system, as necessary, so that highway costs are paid by motor vehicle operators in proportion to their use of the highway system. The project was divided into two tasks:

1) the performance of a cost allocation study comparing highway revenues collected from specific users with the costs occasioned in providing them with highway service. The objective of this study was to determine if all users are equitably sharing highway costs.

2) the investigation of Montana road user tax policy, subsidies, and vehicle tax/fee/permit schedules. The objective of this investigation is to formulate recommendations, as appropriate, to improve the motor vehicle tax system and to address any inequities in the system identified in the cost allocation study.

Initial effort focused on the first task, that is, the completion of a basic cost allocation study, and this report documents the results of this effort. Work is still underway on the second task and will be documented in a separate report.

This cost allocation study specifically addressed the relative equity of the taxes and fees paid by various highway users to the state of Montana with respect to the expenditures by the state to provide these users with highway service. Highway revenue collected and spent by the federal government was not included in the study. The study considered equity between three broad categories of vehicles, namely, basic, intermediate, and heavy vehicles. Basic vehicles included automobiles, motorcycles, vans, pickups, and any other vehicle with a gross weight less than 10,000 pounds. Intermediate vehicles generally consisted of busses and single unit trucks with two axles and average operating weights less than 26,000 pounds. Heavy vehicles generally consisted of those vehicles with operating weights in excess of 26,000 pounds and included single unit trucks with three or more axles and all truck and trailer combinations. To assess the relative equity of the motor vehicle tax structure, state revenues and expenditures on the highway system over a 4 year period (1988 to 1991) were analyzed and allocated to these three classes of users. An average equity ratio, defined as the ratio of allocated revenue to allocated costs, was calculated for each user group.

Equity ratios less than one indicated under payment by that group for use of the system; correspondingly, equity ratios greater than one indicated over payment for use of the system.

Over the four year study period, it was determined that basic, intermediate, and heavy vehicles were responsible for 64, 10, and 26 percent of highway revenues, respectively. The primary highway revenue considered in the study consisted of (a) collections from gross weight fees, the new car sales tax, and fuel taxes, and (b) disbursements from the coal tax trust fund and the proceeds of bond sales and bond interest. Conceptually, allocation of the former type of revenue, which was directly derived from users, was straight forward. These revenues were allocated to the three classes of vehicles in the manner in which they were collected. The latter type of revenue, of a more general source, was allocated presuming the intent was to provide equal benefit and service to all users. Thus, these revenues were shared "equally" between users based on the relative vehicle miles travelled on the highway system by each class of vehicle.

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent, respectively, of the state expenditures on the highway system over the study period. The major highway expenditures considered herein included the costs of the general operation of the Department of Transportation, operation of the Motor Carrier Services Division, highway construction, highway maintenance, bond principal and interest payments, and operation of the highway patrol. Several different methods were used to allocate these costs to the three vehicle classes, based on the specific activities associated with the expenditures involved. Generally, the costs of activities that were independent of the specific vehicle involved were allocated based on relative miles traveled by each class of vehicles. An example of such an activity/cost is the cost associated with signs and traffic signals. Costs that were influenced by the specific characteristics of the vehicles using the system were assigned, as possible, to each user class based on that characteristic of the vehicle. An example of such an item is the cost associated with winter sanding. The frequency that sanding must be repeated in the winter was judged to be related to the number of axle passages rather than the number of vehicle passages over a section of road. Thus, sanding costs were allocated to the vehicle classes based on the relative number of axle miles travelled by each class.

Construction and maintenance costs were a significant part of the total expenditures on the highway system (approximately 66 percent). Construction costs were analyzed using a basic facility approach. The cost of a highway to carry only basic vehicle traffic was uniformly shared across all users based on vehicle miles traveled. Additional costs to carry heavier traffic and vehicle loads were simply added to this cost and were allocated based on the relative physical demand placed on the

pavement by the vehicles in the various user classes (physical demand was quantified using the AASHTO ESAL concept). Pavement maintenance costs were split into costs occasioned due to weathering and aging related deterioration of the pavement and load related deterioration of the pavement. Weather and aging related costs were shared among users based on the relative miles travelled by each user class; costs associated with load related deterioration were allocated based on the physical demand placed on the pavement by the various vehicle classes. Allocation of both construction and maintenance costs was done individually for each study year and independently for interstate, primary, urban, and secondary highways.

The equity ratios determined from the allocation of state revenues and expenditures on the highway system were 0.96, 1.11, and 1.07, respectively, for basic, intermediate, and heavy vehicles. Thus, basic vehicles relatively under paid for their use of the highway system, while intermediate and heavy vehicles relatively over paid for their use of the system. These results are reasonable, based on the results of cost allocation studies conducted in other states. In evaluating these results, it is important to recognize that these ratios only indicate relative equity between user classes; they do not indicate if the absolute amount of revenue collected is sufficient to cover the absolute amount of expenditures. In the last two years of the study period (1990 and 1991), absolute expenditures on the highway system significantly exceeded revenues.

While these results were determined based on four years of historical data, it is believed they reflect revenue and expenditure patterns that will be valid over the next few years. Note that the Surface Transportation Act passed by the federal government in early 1992 will have an impact on the highway system. This impact is expected to be gradual.

Approaches to modifying the revenue structure to address the inequities in user payments found in this study were tentatively explored. A 400 percent increase in the new vehicle sales tax, for example, resulted in equity ratios between 0.98 and 1.01 for all vehicle classes. Alternatively, increasing the gasoline tax by 22.5 percent ($0.045 per gallon increase) resulted in equity ratios of approximately 0.98 for basic and heavy vehicles. The equity ratio for intermediate vehicles, however, increased from 1.11 to 1.14 in response to this action. Formal recommendations for changing the tax structure can not be formulated without completing a thorough review of the entire motor vehicle revenue structure.

ACKNOWLEDGEMENTS

An advisory committee was formed at the beginning of this investigation to review the study methodology and provide a broad perspective on various study issues. In addition to the authors of the study, committee members included Glenna Obie from AAA Montana, Ben Haavdahl from the Montana Motor Carriers Association, and David Galt from the Montana Department of Transportation. The participation of these individuals in the study process is gratefully acknowledged. The advice and encouragement provided by Keenan Bingham and Robert Garber at the Montana Department of Transportation is also gratefully acknowledged. Without exception, the response of the various divisions of the Montana Department of Transportation to requests for information to support the study were courteous, prompt, and professional.

Special thanks are extended to Russ Law, Chuck Bosch, and the other personnel at the Nevada Department of Transportation who graciously shared their time and expertise with us at the beginning of the study.

INTRODUCTION

General Remarks

Traditionally, of the many services provided by government, the highway system is partially or completely paid for by the people that use it. User fees take several forms, including fees related to the amount of use and level of demand a vehicle places on the system (e.g., fuel taxes and gross weight fees, respectively) and fees independent of these parameters (e.g., flat registration fees). The monies collected from the users, possibly supplemented by public funds of a more general source, are then spent to build and maintain the highway system in such a fashion as to provide an equal service and benefit to all. Under an equitable fee system, the monies collected from (and/or associated with) each user will be equal to the expense of providing that user with highway service. The fairness of the fee structure can be determined by comparing revenues to expenditures for various classes of users. Investigations of this kind are commonly referred to as motor vehicle cost allocation studies or cost responsibility studies. The most recent cost allocation study for Montana was conducted in 1957 (Johnson, 1957). As highway use and expenditure patterns can change over time, the 1991 Montana state legislature requested that a new cost allocation study be conducted. The results of this study will be considered in determining changes in the motor vehicle fees collected by the state of Montana.

Objective and Scope

The objectives of this project are to:

1) conduct a cost allocation study for the state highway system to determine if highway costs are equitably shared by vehicle operators in proportion to their use of the highway system.
2) to review the motor vehicle fee structure in the state of Montana and recommend appropriate changes based on present patterns of highway use, the results of the cost allocation study, and current practice nationwide.

Initial effort focused on the first objective, that is, the completion of a basic cost allocation study. The results of this study are presented in this report. Work on the second objective, developing recommendations for revising the motor vehicle fee structure, is underway and will be documented in a second report.

The cost allocation study conducted in this investigation specifically addressed the relative equity of the highway fees paid by motor vehicle operators to the state of Montana, independent of fees paid to the federal government. Correspondingly, the study only considered state revenues and state expenditures on the highway system in evaluating the equity situation. To conduct the study, these revenues and expenditures over a four year period (1988 to 1991) were allocated to three broad classifications of highway user, namely, basic (light) vehicles, intermediate vehicles, and heavy vehicles. An average equity ratio, defined as the ratio of allocated revenue to allocated expenditures, was calculated for each vehicle class. The equity ratios calculated for basic, intermediate, and heavy vehicles were 0.96, 1.11, and 1.07, respectively. Thus, basic vehicles were found to be nominally under paying for their use of the highway system; intermediate vehicles and heavy vehicles, nominally over paying for their use of the system.

STUDY DATA AND METHODOLOGY

General Remarks

The steps involved in conducting a cost allocation study consist of:

1) defining the highway system to be considered,
2) identifying the various users of this system and quantifying their level of demand,
3) identifying the source and amount of revenues and expenditures on the system,
4) allocating these revenues and expenditures to various users, and
5) comparing revenue and expenditures by user type to determine equity.

Information on the highway system, highway users, and revenues and expenditures was generally provided by the Montana Department of Transportation (MDT). Approaches for allocating revenues and expenditures to various vehicles were determined after extensive review of the available literature on cost allocation studies.

Highway System

This study was specifically concerned with those highways in the state of Montana for which the MDT assumes responsibility. In 1991, MDT participated in the operation and maintenance of approximately 12,900 miles of highways. A summary of these highways is presented in Table 1 in terms of both their federal aid and functional classification. The exact mileage of highways in the state inventory continually changes, as routes are upgraded, downgraded, re-built, and added or dropped from the system in response to changing traffic demands. A comparison of the mileage reported in each unit of the system in 1989 and 1991 indicated little change (less than 0.1 percent) in the system configuration over the four year study period (MDT, 1989 and 1991). Note that approximately 11,800 miles of highway in the state system (91 percent) is included in the federal aid system. The federal government will share the cost of certain activities on federal aid highways with the state. In general, major reconstruction and rehabilitation work qualify for cost sharing, with the federal government paying 80 to 90 percent of the total cost of such projects.

For the cost allocation study, highway use and expenditures were analyzed, as appropriate, on each unit of the federal aid system. Any differences in traffic patterns or in construction and maintenance philosophies between the systems thus were incorporated in the study. While

Table 1. State Highway System Mileage by Federal Aid System and Functional Class.

Federal Aid System	Functional Class					
	Interstate	Principal Arterial	Minor Arterial	Major Collector	Off System	TOTAL
Interstate						
Rural	1144					1144
Urban	47					47
Total	1191					1191
Primary						
Rural		2102	3249			5351
Urban		101				101
Total		2203	3249			5452
Secondary				4756		4756
Urban		70	190	101		361
Off System					1139	1139
TOTAL	1191	2273	3439	4857	1139	12899

Source: 1991 Montana Federal Aid Road Log (MDT, 1991)

differences in use and expenditures between various highways may be more closely and rationally tied to functional class than federal aid class, data were found to be readily available by federal aid classification. Note that in Montana, functional and federal aid classifications are closely correlated.

Highway Users

Three primary classifications of highway user were considered in this study, namely, basic vehicles, intermediate vehicles, and heavy vehicles. Basic vehicles consisted of passenger cars, pickups, vans, and recreational vehicles with registered gross weights of less than 10,000 pounds. Intermediate vehicles consisted of 2 axle single units and busses with registered weights generally greater than or equal to 10,000 pounds but less than 26,000 pounds. Heavy vehicles included all 3 or more axle single units with registered weights generally greater than or equal to 26,000 pounds and all combinations of power units or trucks with trailers. Information on highway use for these classes of vehicles was provided by the Traffic Data Collection Section of MDT. MDT monitors highway

use by vehicle configuration, using the 21 configurations listed in Table 2. The assignment of these configurations to the vehicle classifications used for the cost allocation study are also shown in Table 2.

Highway use can be expressed in terms of several parameters, including vehicle miles travelled (VMT), axle miles traveled (AMT), ton miles traveled (TMT), and ESAL miles traveled (ESAL-M). VMT is simply the number of vehicles on a highway multiplied by the miles they travel over some time interval. If additional information is available concerning specific characteristics of the vehicles, AMT, TMT and ESAL-M can be calculated from VMT. For a specific vehicle configuration, AMT can be calculated as the number of axles for that vehicle type multiplied by its VMT. Similarly, if weight data is available, TMT can be simply calculated as the weight per vehicle (in tons) multiplied by its VMT. ESAL-M can also be calculated by multiplying the ESAL factor for a vehicle by its VMT. The ESAL factor for a vehicle is an indication of the physical demand that the passage of that vehicle places on the roadway (particularly on the base and wearing surface). The ESAL concept was developed for design purposes to calculate a design demand on a roadway subjected to a mixed stream of vehicles. The ESAL factor of a vehicle is related to both the type of axles on the vehicle, the loads they carry, and the type of pavement on which the vehicle is operated. The factor represents the number of passages of an 18,000 pound single axle that would damage the pavement an amount equivalent to the single passage of the vehicle in question (equivalent single axle load, ESAL). For a particular vehicle, the ESAL factor is calculated as the sum of the ESAL values for each axle comprising the vehicle. Relationships between axle loads and ESALs were developed from the results of the AASHO Road Test (Highway Research Board, 1962). The relationship between ESAL factor and axle load is non-linear, that is, as axle load increases, the ESAL factor increases in a fourth order relationship.

The traffic data used in this study is summarized in Tables 3 and 4. Data was only available for 1988, 1989, and 1990 at the time the study was initiated (the 1991 traffic data was still being processed). The 1990 data was used for 1991 throughout the study. This approximation is believed to have only nominally effected the study results. Note that in most applications, the study utilized the relative proportion of different types of vehicles in the traffic stream, rather than the absolute volume of traffic.

Data on highway use is collected through vehicle counts, classification surveys, and weigh station activities. For the interstate and primary systems, information obtained by MDT from visual classification counts conducted simultaneously with weight measurements was most useful. The data

Table 2. User Classifications (Vehicle Configurations).

Description	Average Operating Weight, lbs	Number of Axles	Average Operating ESALs
Basic Vehicles			
Pass. Car,	2,500	2	0.0002
Light Truck, Vans, RV	6,000	2	0.0023
Intermediate Vehicles			
Busses	25,000	3	0.257
2 Axle/4 Tire	12,000	2	0.0342
2 Axle/6 Tire	15,960	2	0.344
Heavy Vehicles			
3 Axle, Single Unit	30,160	3	0.607
4+Axle, Single Unit	52,080	4+	1.392
3 Axle Semi	28,100	3	0.643
4 Axle Semi	32,248	4	0.548
5 Axle Semi	64,390	5	1.527
6 Axle Semi	68,462	6	1.691
3 Axle Trk, Full Tr	19,500	3	0.314
4 Axle Trk, Full Tr	23,260	4	0.289
5 Axle Trk, Full Tr	69,000	5	1.965
6 Axle Trk, Full Tr	72,489	6	1.468
5 Axle Semi, Full Tr	64,489	5	1.980
6 Axle Semi, Full Tr	62,571	6	1.414
7 Axle Semi, Full Tr	78,710	7	1.825
8 Axle Semi, Full Tr	91,401	8	1.574
7 Axle, Triple Tr	86,976	7	2.498
8 Axle, Triple Tr	88,976	8	2.918

consisted of traffic counts broken down by vehicle configuration coupled with the average weight carried on each axle of each configuration. The weight data was used to calculate average operating weights and ESAL factors for each vehicle configuration (see Table 2). The vehicle ESAL factors were calculated as the sum of the axle ESAL factors, which were determined using the AASHTO Guide for Design of Pavement Structures (AASHTO, 1986) assuming a flexible pavement with a structural number (SN) of 5 and a terminal serviceability of 2.5. The ESAL factors for each vehicle

configuration and year were averaged to obtain the factors used in calculating ESAL-M for each year of the study from VMT.

Referring to Table 3, vehicle use of the highway system gradually increased between 1988 and 1990 (recognizing that the physical miles of highway in the system was approximately the same over all years). The relative proportion of basic, intermediate, and heavy vehicle traffic, however, remained fairly constant during this time. Basic vehicles were responsible for the majority of VMT (84 percent). Intermediate and heavy vehicles were only responsible for 7 and 9 percent of VMT, respectively. Conversely, basic vehicles were only responsible for 1 percent of ESAL-M, compared to 11 percent for intermediate vehicles and 88 percent for heavy vehicles.

From Table 4, most of the vehicular use of the highway system in terms of miles travelled was on the rural primary and interstate systems. The primary rural system accounted for 40 percent of total VMT and TMT, and 39 percent of ESAL-M. The rural interstate system accounted for only 30 percent of VMT, 40 percent of TMT, and 47 percent of ESAL-M. Note that the data available for secondary roads was sparse, and the values listed in Table 4 for secondary roads are considerably less certain than those for primary roads and the interstate.

Study Period

Four years of historical revenue and expenditure data were considered in performing this cost allocation study. By considering several years in the study period, the influence of episodic fluctuations in spending and system use on the study results were minimized. The four years selected for the study were fiscal years 1988 through 1991. Construction of possibly the last new major highway system in Montana (the interstate system) was completed in 1988. Beginning in 1988 and extending into the years thereafter, expenditures focused on reconstruction and maintenance betterment activities, a pattern which is expected to continue for at least the next few years (Kologi and Bingham, 1992). Based on the uniformity of the traffic data for 1988 to 1990, radical changes in vehicle types and traffic patterns are not expected in the near future.

One factor that will have a long term impact on the highway system in Montana is the Surface Transportation Act passed by the federal government in early 1992. The federal aid highway system was re-organized under this act, altering the status of several specific routes within the state. The act also established new state/federal cost share ratios for reconstruction work on the federal aid highways. The total aid available from the federal government for cost shared projects will also increase compared to previous years. While all the ramifications of the act are still being investigated,

its impact on the highway system and highway funding is expected to be gradual (Kologi and Bingham, 1992).

Table 3. Summary of Traffic Data by Years, All Systems.

Measure of Use	Average Daily Use		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
1988			
VMT	13,161,601	1,126,417	1,392,800
TON-M	25,356,645	8,713,623	38,725,137
AXLE-M	26,333,946	2,467,740	6,699,100
ESAL-M	13,201	241,213	1,847,420
1989			
VMT	13,720,732	1,176,244	1,459,920
TON-M	26,330,183	9,071,266	40,533,884
AXLE-M	27,359,386	2,560,668	7,009,790
ESAL-M	13,701	248,202	1,937,257
1990			
VMT	14,077,284	1,210,723	1,505,199
TON-M	26,961,659	9,261,102	41,794,371
AXLE-M	28,049,516	2,624,208	7,219,779
ESAL-M	13,971	252,013	1,996,143

Source: Traffic Data Collection Section, MDT

Table 4. Average Traffic Over the Study Period by Federal-Aid System.

Federal Aid System	Average Daily Use			
	VMT	TMT	AMT	ESAL-M
Interstate				
Rural	4,751,554	30,308,793	11,622,460	1,018,494
Urban	414,669	2,326,876	989,059	82,951
Primary				
Rural	6,719,110	29,966,512	15,101,879	848,944
Urban	1,128,310	3,300,737	2,363,351	60,808
Secondary	1,424,989	5,667,125	2,998,668	150,510
Urban	1,838,342	4,012,580	3,699,295	25,999

Revenue and Expenditures

Basic data on highway department revenues and expenditures over the 4 year study period were provided by the Financial Management Bureau of MDT. A summary of this information is presented in Table 5; the complete cash flow table from which this information was obtained is presented in Appendix A. Note, once again, that the revenues and expenditures considered in this study are only the state share of monies collected and spent on the state highway system. The federal government collects significant highway user fees and is a major source of construction funds for highways included in the state system. The state of Montana, however, has only nominal influence on the federal highway revenue system and construction expenditure program. Furthermore, the state and federal governments maintain a clear distinction between their fiscal systems. In light of this situation, revenues and expenditures by the state on the highway system can be reasonably studied independently of those of the federal government.

Allocation Process

This cost allocation study was conducted by assigning the highway revenues and expenditures listed in Table 5 to the various classes of vehicles responsible for them. Commonly used allocation techniques are described in such documents as the "State Guide to Highway Cost Allocation" published by the Federal Highway Administration (FHWA, 1984) and the "Rationalization of Procedures for Highway Cost Allocation" by the Urban Institute, et. al. (1990). Specific implementation of these approaches is well documented in the various cost allocation studies completed by states around the nation. A federal survey conducted in 1990 (AASHTO, 1990) found that 21 states had completed cost allocation studies between 1977 and 1990 and that 7 other states had studies underway. Some states (e.g., Oregon and Nevada) routinely revise their studies in acknowledgement of the dynamic nature of highway use and expenditures.

Conceptually, allocation of most revenue was straight forward, in that the revenue was assigned to those vehicles from which it was collected. Practically, revenue allocation is complicated by the fact that most accounting systems maintain records of total revenue collected and not the specific source of this revenue. For example, while $67,014,519 in gas tax revenue is listed in Table 5 for FY '88, no direct record exists if this revenue was collected from compact cars (basic vehicle) or busses (intermediate vehicle). Therefore, indirect methods were often employed in the revenue allocation process.

Table 5. Revenue and Expenditure Data for the Cost Allocation Study.

Item	FY '88	FY '89	FY '90	FY '91
Beginning Cash Balance	$126,618,131	$141,623,591	$146,222,162	$129,913,204
REVENUE				
Gross Weight Fees	13,335,103	13,930,613	14,484,637	14,163,160
Sales Tax on New Vehicles	5,503,227	6,271,576	7,041,066	6,269,773
Miscellaneous Fees Collected by M.C.S. Division	5,136,417	5,071,764	5,212,522	4,743,787
Gasoline Fuel Tax	67,014,519	70,069,172	69,739,270	68,551,154
Diesel Fuel Tax	19,699,828	21,184,583	22,233,781	21,246,525
Coal Tax Trust Fund	10,156,597	7,027,869	8,144,464	6,054,941
Bond Proceeds and Earnings	9,080,153	6,200,687	3,925,575	725,549
Miscellaneous Accounts Receiveable	2,094,154	2,075,961	4,912,125	3,673,793
ACI Reimbursement	7,489,996	0	0	0
Supplement from Cash Balance	0	0	16,308,422	39,238,516
TOTAL REVENUE	$139,509,994	$131,832,225	$152,001,862	$164,667,198
EXPENDITURES				
M.C.S. Division Operations	3,392,515	3,377,012	3,370,452	3,485,987
General Operations	8,725,947	6,840,035	7,059,402	7,359,166
Pre-Construction	3,847,939	4,607,207	5,028,133	6,737,771
Construction	46,999,540	53,336,864	70,342,059	81,714,233
Maintenance	40,968,264	42,121,180	44,480,936	45,863,441
Bond Principal and Interest	10,041,082	10,041,083	10,041,083	9,741,178
Dept. of Justice	9,708,600	9,957,471	10,885,348	10,987,488
Misc. Expenditures	820,917	(3,046,662)	794,449	(1,222,066)
TOTAL EXPENDITURES	$124,504,534	$127,234,190	$152,001,862	$164,667,198
Contribution to Cash Balance	15,005,460	4,598,035	0	0
TOTAL	139,509,994	131,832,225	152,001,862	164,667,198

Several different methods were employed to allocate highway expenditures to the various classes of vehicles, based on the activities associated with the expenditures involved. Generally, the costs of activities that were independent of the specific vehicle involved were allocated based on VMT. An example of such an activity/cost is the cost associated with road signs. Costs occasioned by demands related to specific attributes of vehicles were allocated, as possible, based on that attribute. The frequency that sanding must be repeated in the winter, for example, was judged to be related to the number of axle passages rather than the number of vehicle passages. Thus, sanding was allocated based on AMT.

Throughout this report, allocation strategies employed in other studies are cited with respect to those selected for use in this study. The results obtained in other states from the allocation process are compared, as possible, with the results obtained herein.

REVENUE ALLOCATION

General Remarks

Basic, intermediate, and heavy vehicles were found to be responsible for 64, 10, and 26 percent of state highway revenues, respectively. The allocation of specific types of revenue to the three vehicle classes is summarized in Table 6. The allocation factors used in each year of the study

Table 6. Summary of Revenue Allocation.

Source	Avg. Annual Revenue, FY 88-91	Allocation Methodology	% Basic	% Inter.	% Heavy
Gross Weight Fees	$13,978,378	To various vehicle categories as collected	14	12	74
Sales Tax on New Vehicles	6,271,411	To various vehicle categories as collected	88	4	8
Misc. Fees Collected by Motor Carrier Services	5,041,123	To intermediate and heavy vehicles based on AMT	0	27	73
Gasoline Fuel Tax	68,843,529	To all vehicles based on expected mpg and VMT	86	12	2
Diesel Fuel Tax	21,091,179	To all vehicles based on expected mpg and VMT	8	6	86
Coal Tax Trust Fund	7,845,968	To all vehicles based on VMT	84	7	9
Bond Proceeds and Earnings	4,982,991	To all vehicles based on VMT	84	7	9
Miscellaneous Accts Receiveable	3,189,008	To all vehicles based on VMT	84	7	9
ACI Reimbursement	1,872,499	To all vehicles based on construction cost responsibility	65	9	26
Supplement from Cash Balance	13,886,734	To all vehicles as contributed to cash balance	77	8	15
TOTAL	147,002,820	-	**64**	**10**	**26**

period for the different types of revenue are listed in Table 7. The revenue considered for allocation in this study can be divided into two broad categories, namely, (1) fees paid directly by users, consisting of fuel taxes, the new vehicle sales tax, and weight taxes, and (2) revenue not derived from specific users, consisting of interest earnings on bonds, revenue from the Coal Tax Trust Fund, etc. Over the four year study period, the average annual revenue collected was $131,116,085 dollars. Approximately 90 percent of this revenue was from direct user fees; 10 percent, from non-specific sources. As possible, direct user fees were allocated as they were collected. Non-specific fees were generally allocated by VMT to all users. Note that in 1988 and 1989, revenues exceeded expenditures, and thus money was contributed to the MDT working cash balance. Conversely, in 1991 and 1992, expenditures exceeded revenues, and monies had to be withdrawn from the working cash balance.

Allocation of Fuel Taxes

Gasoline and diesel fuel tax revenue was allocated to the three vehicle classes based on estimates of fuel consumption rates and distance travelled. As might be expected, basic vehicles were responsible for most of the gasoline tax revenue (86 percent), while heavy vehicles were responsible for most of the diesel tax revenue (86 percent). The current fuel tax in Montana is $0.20 per gallon of gasoline and diesel fuel (Montana Code Annotated (M.C.A.), 1991). The information available on fuel tax revenue simply consisted of the total gallons taxed and total revenue collected each year, as shown in Table 8.

A portion of the fuel tax revenue is passed through MDT to cities and counties for use on local roads. The fuel tax revenue reported in the cash flow sheet in Appendix A was reduced by this amount (approximately $14,146,250 annually). The majority of this local road disbursement (approximately 75 percent) was deducted from the gasoline tax revenue. The assumption was made that lighter gasoline powered vehicles were responsible for more of the use of local roads than heavier diesel powered vehicles. Initially, two approaches were considered for deducting the local road disbursement, namely, (a) deducting the disbursement entirely from gasoline tax revenues, and (b) deducting the disbursement from gasoline and diesel fuel revenues in the proportion in which the taxes on these fuels were collected. Finally, the local road disbursement was divided between gasoline and diesel fuel using the average of the results obtained from these two approaches.

The first step in allocating fuel revenues was to estimate the percentage of each vehicle configuration that used gasoline versus diesel fuel. The miles travelled by each vehicle type using

Table 7. Revenue Allocation by Study Year.

Revenue	Allocation, 1988			Allocation, 1989			Allocation, 1990			Allocation, 1991			Allocation, Over-all		
	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV
Gross Weight Fees	0.14	0.13	0.73	0.13	0.12	0.75	0.13	0.11	0.76	0.14	0.13	0.73	0.14	0.12	0.74
Sales Tax on New Vehicles	0.88	0.03	0.09	0.88	0.03	0.09	0.89	0.04	0.07	0.88	0.05	0.07	0.88	0.04	0.08
Misc. Fees Collected by M.C.S. Division	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73
Gasoline Fuel Tax	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02	0.86	0.12	0.02
Diesel Fuel Tax	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86	0.08	0.06	0.86
Coal Tax Trust Fund	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Bond Proceeds and Earnings	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Miscellaneous Accounts Receiveable	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
ACI Reimbursement	0.65	0.09	0.26	+	+	+	+	+	+	+	+	+	0.65	0.09	0.26
Supplement from Cash Balance	*	*	*	*	*	*	0.77	0.08	0.15	0.77	0.08	0.15	0.77	0.08	0.15
Total Revenue	0.64	0.10	0.26	0.62	0.11	0.27	0.64	0.10	0.26	0.65	0.10	0.25	0.64	0.10	0.26

BV - Basic Vehicle
IV - Intermediate Vehicle
HV - Heavy Vehicle
* - No supplement was required
\+ - No revenue

Table 8. Summary of Fuel Tax Revenues.

Fiscal Year	Gasoline		Diesel	
	Taxable Gallons	Total Tax	Taxable Gallons	Total Tax
1988	443,275,215	$85,576,181	115,431,120	$22,389,970
1989	442,819,163	88,563,833	117,149,919	23,429,984
1990	444,634,725	88,926,945	122,858,459	24,571,692
1991	437,859,988	87,571,998	118,384,584	23,676,917

Source: Accounting Services, MDT (Miros, 1992)

gasoline and diesel fuel were calculated based on these percentages. Estimates of the gallons of fuel used by each vehicle configuration were then obtained by dividing the miles travelled using each fuel type by the expected miles per gallon for that vehicle configuration. Projected tax revenues from each vehicle type were calculated by multiplying the estimated gallons consumed by the $0.20 per gallon tax rate. Fuel tax revenue allocators were calculated as the ratio of the projected revenue from each vehicle class divided by the total projected revenue. Finally, the fuel tax revenue allocated to each vehicle class each year was determined by multiplying the actual annual fuel tax revenue by these revenue allocators.

Estimates of the percentage of each vehicle configuration that used gasoline and diesel fuel were found in the 1987 California Cost Allocation Study (Sydec, 1987) and are presented in Table 9. These estimates apparently were based on forecasts presented in an earlier report by Systems Design Concepts, Inc. (1981). The percentage of gasoline versus diesel vehicles within each vehicle configuration were also estimated from information presented in the State Highway Cost-Allocation Guide prepared by the Federal Highway Administration (1984); these estimates are also presented in Table 9. The splits between gasoline and diesel vehicles reported by these two sources are generally similar. The split from the California Highway Cost Allocation Study was used in this study, as the California study is nominally more current than the State Highway Cost-Allocation Guide, and the California split schedule is somewhat more complete. The vehicle miles travelled using gasoline and diesel fuel were simply calculated for each vehicle configuration by multiplying VMT by the appropriate factors in Table 9.

The gallons of gasoline and diesel fuel used by each vehicle configuration were estimated by dividing the miles travelled using that type of fuel by an estimated consumption rate (i.e. miles per

Table 9. Split, Gasoline Versus Diesel Fuel by Vehicle Configuration.

Vehicle Configuration	California Highway Cost Allocation Study (Sydec, 1987)		State Highway Cost-Allocation Guide (FHWA, 1984)	
	Percent Gasoline	Percent Diesel	Percent Gasoline	Percent Diesel
Autos	97.5	2.5	98.5	1.5
Motorcycles	100.0	0.0	100.0	0.0
Pickup, Van, Rv	97.0	3.0	98.5	1.5
Busses	73.5	26.5	83.0	17.0
SU - 2 Axle	88.0	12.0	93.0	7.0
SU - 3+ Axle	43.5	56.3	31.5	68.5
Comb. 3 Axle	23.5	76.5	0.0	100.0
Comb. 4 Axle	15.5	84.5		
Comb. 5+ Axle	2.0	98.0	0.0	100.0

gallon) for that configuration. Estimated fuel consumption rates presented in the California cost allocation study (Sydec, 1987) are presented in Table 10. Also presented in Table 10 are estimated fuel consumption rates determined from information presented in the State Highway Cost Allocation Guide (FHWA, 1984). While the miles per gallon generally decrease as vehicle size increases in both studies, considerable variation exists between the specific gasoline and diesel miles per gallon reported for various vehicles. Additional information on fuel consumption rates was obtained from Highway Statistics published by FHWA (1988, 1990) and is reported in Table 11. This information consisted of average miles per gallon (single value for both fuel types) by year. The miles per gallon values reported in Table 11 (similar to those reported in Table 10) were used in this study. The 1990 values were also used for 1991.

Based on the miles per gallon figures in Table 11, and VMT data for each vehicle configuration, the gallons of gasoline and diesel fuel used for travel on the state highway system by each user class were calculated. If the fuel tax revenue provided to local governments is converted to equivalent gallons of fuel used and added to these gallonages, the total estimates of gallons of gasoline and diesel fuel used each year are approximately 12 and 9 percent less than the actual gallons of gasoline and diesel fuel taxed each year (see Table 12). This difference at least partially represents the fuel used for non-highway related operations, particularly with respect to gasoline.

Table 10. Fuel Consumption Rates, Gasoline and Diesel Vehicles.

Vehicle Configuration	Miles per Gallon California Cost Study (Sydec, 1987)		Miles per Gallon State Highway Cost Allocation Guide (FHWA, 1984)	
	Gasoline	Diesel	Gasoline	Diesel
Autos	20.6*		16.6	28.4
Motorcycles	50.0*		50.0	-
Pickups, Vans, RVs	15.1*		14.3	17.9
Busses	5.2*		7.4	4.4
SU - 2 Axle	7.6	11.0	7.4	9.3
SU - 3+ Axle	5.0	5.3	6.0	4.9
Comb. 3 Axle	4.5	6.1	5.3*	
Comb. 4 Axle	4.4	5.6		
Comb. 5 Axle	4.2	5.2	-	4.6

SU - Single Unit
* - single value given

Table 11. Fuel Consumption Rates for 1988, 1989, and 1990.

Vehicle Configuration	Miles Per Gallon, Mixed Gasoline and Diesel Vehicles		
	1988	1989	1990
Passenger Cars	20.0	20.3	20.9
Busses	5.9	6.0	6.4
SU, 2 Axle, 4 Tire	13.4	13.8	14.1
Other SU	7.1	7.5	7.3
Combinations	5.3	5.5	5.5

SU - Single Unit
Source: Highway Statistics, 1988 and 1990 (FHWA, 1988, 1990)

Table 12. Comparison of Actual and Projected Gallons of Fuel Taxed.

Fuel Type	Actual Gallons Taxed (Annual Average)	Projected Gallons Taxed (Annual Average)			Ratio, Calculated to Actual Gallons Taxed
		From Analysis of State System Traffic Data	From Analysis of Local Government Allotment	Total Gallons From Analysis	
Gasoline	442,758,801	328,766,108	63,045,365	391,811,473	0.88
Diesel	119,832,102	101,035,600	7,685,885	108,721,485	0.91

Less non-highway consumption of diesel fuel might be expected than indicated herein, and the disparity in estimated and actual gallons of diesel fuel taxed may indicate inaccuracies in the consumption rates assumed for diesel powered vehicles.

The projected gallons of fuel consumed each year were multiplied by the $0.20 per gallon tax rate to obtain a projected tax revenue for each vehicle class. Allocators for the actual fuel tax revenue each year were calculated as the ratio of the projected revenue from each vehicle class to the total projected revenue.

New Vehicle Sales Tax

Revenue from the new vehicle sales tax was approximately allocated to the vehicles from which it was collected. Basic, intermediate, and heavy vehicles were assigned 88, 4, and 8 percent of the revenue collected over the study period. The new vehicle sales tax is collected on all sales of new motor vehicles (except trailers, semitrailers, and housetrailers) in consideration of the right to use the state highways (M.C.A., 1991). Depending on the type of vehicle and date purchased, this tax ranges from 0.004 to 0.015 of the list price of the vehicle. The available sales tax data is summarized in Table 13.

Sales tax collected on cars and motorcycles was allocated to basic vehicles. Taxes collected on truck sales were split between basic, intermediate, and heavy vehicles. From vehicle registration data for 1990 (Montana Department of Justice, 1991), approximately 89 percent of the trucks weighing less than 26,000 pounds were basic vehicles (gross vehicle weight of less than 10,000 pounds). Assuming vehicles of this size and type are generally replaced in the same proportion at which they are registered, approximately 89 percent of the new trucks purchased were basic vehicles. Further assuming that variations in list prices, tax rates, and replacement rates average out across this

Table 13. New Vehicle Sales Tax Data.

Fiscal Year	New Vehicle Sales Tax Collected				
	Total	Cars Motorcycles	Trucks under 26,000 lbs	Trucks over 26,000 lbs	Tractors
1988	$6,693,526	$4,468,892	$1,797,191	$84,523	$342,920
1989	6,596,721	4,197,223	1,940,904	73,620	384,974
1990	6,376,887	3,589,585	2,202,657	73,626	511,019
1991	5,771,130	2,591,925	2,617,634	*23,361	538,210

* possible error, calculations done using 1990 value
Source: Motor Carrier Services Division, MDT (Ala, 1992)

group of vehicles, 89 percent of the sales tax revenue collected from trucks weighing less than 26,000 pounds was assigned to basic vehicles. The remainder of the revenue from trucks weighing less than 26,000 pounds was assigned to intermediate vehicles. All of the revenue from trucks weighing at least 26,000 pounds and tractors was assigned to heavy vehicles.

Gross Weight Fees

Basic, intermediate, and heavy vehicles were assigned 14, 12, and 74 percent of the gross weight fees collected, respectively. Gross weight fees are collected annually on motortrucks, truck tractors, trailers, and semitrailers, as established by state law (M.C.A., 1991). The magnitude of the fees are generally related to the type and gross weight of the unit to be licensed. For vehicles with gross weights exceeding 24,000 pounds, annual fees can be prorated to the nearest month based on that part of the year that the vehicle will actually be used. The available data on gross weight revenues varied with the type of user from which it was collected. Different types of records were available for vehicles used only in Montana, vehicles based in Montana that were engaged in inter-state travel, and vehicles engaged in interstate operation that were based out of state. The revenues collected from each of these types of user are summarized in Table 14. The allocators used in assigning this revenue to basic, intermediate, and heavy vehicles are summarized in Table 15.

Allocation of the gross weight fees to the vehicles from which they were collected proved to be a difficult task due to (a) the nature of fee system and (b) the available records. Power units and trailers are generally licensed separately in Montana. Thus, assigning revenue from such units to a

Table 14. Gross Weight Fees Collected During the Study Period.

Fiscal Year	Gross Weight Fees Collected			
	Montana Only*	Interstate, Based in Montana*	Interstate, Based Outside Montana	Total*
1988	$6,754,597	$2,898,152	$3,682,354	$13,335,103
1989	6,754,597	3,052,689	4,123,327	13,930,613
1990	6,733,374	2,948,977	4,802,286	14,484,637
1991	6,873,425	2,933,792	4,355,944	14,163,160

*Source: G.V.W. Division, MDT (Ala, 1992)

Table 15. Allocation of Gross Weight Fees by Source.

Fiscal Year	Montana Only Operators			Interstate Operators, Based in Montana			Interstate Operators, Based Outside Montana		
	BV	IV	HV	BV	IV	HV	BV	IV	HV
1988	0.28	0.23	0.49	0.00	0.04	0.96	0.00	0.00	1.00
1989	0.28	0.23	0.49	0.00	0.02	0.98	0.00	0.00	1.00
1990	0.27	0.22	0.51	0.01	0.06	0.93	0.00	0.00	1.00
1991	0.28	0.24	0.48	0.00	0.06	0.93	0.00	0.00	1.00

specific vehicle combination is uncertain, in that the units can be combined in several ways. The data available on the fees collected varied with the source of the revenue, ranging from a simple lump sum for hundreds of vehicles with no indication of specific source, to the individual fees paid on specific vehicles. Faced with these problems in assigning the gross weight revenue, the decision was made to simplify the allocation process by only attempting to allocate this revenue to the broad categories of basic, intermediate, and heavy vehicles.

The records available on the gross weight fees paid by vehicles that operated exclusively in Montana consisted of the total revenue collected each year and the number of units registered at various weights (in increments of 2,000 pounds) listed by type (truck or trailer) and fee class. This information was available for 1989, 1990, and 1991. The contributions from basic and intermediate vehicles were calculated by multiplying the number of vehicles in the various weight classes (6,000

and 8,000 pounds for basic vehicles and 10,000 to 24,000 for intermediate vehicles) by the corresponding annual fees for each weight class. Contributions from heavy vehicles could not be directly estimated using this procedure, as the fees collected from individual vehicles varied due to proration for partial year registration. Heavy vehicle contributions were simply calculated by subtracting the previously allocated basic and intermediate vehicle contributions from the total revenue collected. The results obtained by this procedure for 1989 were significantly different from those obtained for 1990 and 1991. Therefore, the 1989 fees (for this type of user) were assigned using the average of the percentages allocated to each vehicle class in 1990 and 1991. The revenue and allocation factors established for 1989 were also used for 1988, in the absence of any other information for 1988. Based on these various calculations and assumptions, an average of 28, 23, and 49 percent of this portion of the gross weight fees were assigned to basic, intermediate, and heavy vehicles.

The fee information available for interstate operators based in Montana was fairly detailed, consisting of the specific fees paid by each operator, the type of unit or units involved (single unit, bus, tractor, trailer, or double trailer), the registered weight of each unit, and the number of axles on each unit. Each year, a sampling of the registration fees paid by 65 operators (on a total of approximately 850 vehicles) was randomly selected and analyzed to determine the percentage of fees paid on each class of vehicles. Contributions from single unit trucks with gross weights of 6,000 and 8,000 pounds were assigned to basic vehicles. Intermediate vehicles were credited with those fees paid on 2 axle, single units and busses with weights between 10,000 and 24,000 pounds. All remaining contributions (from heavy single units, tractors, and trailers) were allocated to heavy vehicles. The average proportion of these gross weight revenues paid by basic, intermediate, and heavy vehicles were found to be 0, 5, and 95 percent.

Gross weight fee data for vehicle operators based outside Montana simply consisted of the total amount collected from each state on a monthly basis, and this information was only complete for 1991. Therefore, the amount of revenue generated from this group of vehicles each year was simply calculated by subtracting the revenue from instate and Montana based interstate operators from the total gross weight fees collected. The only information available to verify these figures was the total revenue collected from out-of-state operators in 1991, which was reported to be $5,503,035. This value is approximately 25 percent higher than that calculated by subtracting instate and Montana based interstate revenue from the reported total revenue for 1991. This discrepancy is still under investigation. All revenue from out-of-state operators was allocated to heavy vehicles. Under a

reciprocal fee arrangement, Montana does not collect gross weight fees for vehicles with weights less than 26,000 pounds. Note that an informal visual classification count conducted over a 4 hour period at the Haugan weigh station revealed that 98 percent of the out-of-state based truck traffic were combination units.

Total gross weight fee contributions for each vehicle class were determined each year by summing the contributions from in-state vehicles, interstate vehicles based in Montana, and vehicles engaged in interstate operations that were based out of state.

Coal Tax Trust Fund and Bond Related Revenues

The Coal Tax Trust Fund and Bond Related revenues are not associated with specific classifications of highway user. Presuming the intent of these contributions was to provide equal benefit to all users, it was decided to allocate this income based on VMT. Note that in the Maine cost allocation study (Maine DOT, 1989), a preliminary revenue analysis was performed considering only direct user contributions. The allocation factors determined from this analysis were used to apportion all non-specific revenues to various classes of user. The authors of the Vermont study apparently elected to exclude non-user specific revenues from consideration (Sydec, 1990).

Miscellaneous Motor Carrier Services Income

Miscellaneous revenue collected by the Motor Carrier Services division of MDT primarily consisted of permit fees and fines. These fees and fines were levied almost entirely on intermediate and heavy vehicles. This income was judged to be nominally related to the vehicle configuration as represented by the number of axles. Thus, miscellaneous Motor Carrier Services income was allocated based on AMT to intermediate and heavy vehicles.

Miscellaneous Accounts Receivable

Revenue not readily included in any area discussed above is accounted for in miscellaneous accounts receivable. While specific revenues included in this category vary somewhat from year-to-year, a typical list of accounts receivable for one year is presented in Table 16. These revenues were collectively allocated to various users based on VMT. Note that annual accounting adjustments and corrections to revenue are included in this category.

Table 16. Typical Revenue Included Under Accounts Receiveable (FY 1990).

Revenue Type	Revenue Amount
Sale of Property	$160,705
Leases	89,316
Miscellaneous Receipts	477,294
Transfers-In Coal Board	1,032,929
Administration Fees (Handling Charges)	12,248
Reimbursements	916,853
Administration Fees (Handling Charges)	40,679
City/County Reimbursement	2,021,160
Haugan GVW Scale	111,340
Coal Board Grants	9,188
Coal Board Grant II City/County	53,183
Coal Board Grant II	53,183
TOTAL	4,978,078

Source: MDT Financial Management Bureau (Kirby, 1992)

Advanced Construction Interstate (ACI) Reimbursement

The ACI revenue shown in Table 5 for 1988 consisted of a reimbursement from federal funding sources for state monies spent in previous years to accelerate the completion of the interstate system. As the original expenditures were generally on construction efforts, this reimbursement was allocated to the various classes of vehicles using the allocation factors for construction expenditures.

Supplement from Working Cash Balance

The beginning working cash balance for any given year represents the cumulative difference to-date between revenues and expenditures. At the beginning of FY 1988, the reported working cash balance was $126,618,131. A significant part of this cash balance resulted from the sales of bonds in FY 1987. It was important to consider the source and assignment of this cash balance to the various user classes, in that this cash balance served as income in years that expenditures exceeded revenues (as occurred in 1990 and 1991).

Basic, intermediate, and heavy vehicles were credited with 79, 8, and 13 percent, respectively of the beginning cash balance in FY 1988. Near the end of FY 1987, $150,000,000 in highway bonds were sold. After various fees were paid and outstanding debt retired and accounts consolidated, MDT realized approximately $99,000,000 of revenue from the sale and associated interest earnings. Approximately $3,400,000 of this money was spent in 1987. The remaining funds, $95,600,000 became part of the departmental working cash balance. This $95,600,000 was credited to each vehicle class based on the average VMT over the study period, consistent with the concept that the intent of the bond money was to provide equal service and benefit to all users of the highway system. In the absence of any information regarding the source of the remaining amount in the beginning cash balance, approximately $31,018,131, this money was allocated to various vehicle classes based on the over-all revenue allocators developed for 1988.

In 1988 and 1989, revenues continued to exceed expenditures, and the excess monies were added to the working cash balance. Each year, contributions to the cash balance were allocated based on the over-all allocation factors for the revenue collected that year, and the proportion of the new total working cash balance belonging to each vehicle class was re-calculated. In 1990 and 1991, expenditures exceeded revenues, and monies were withdrawn from the working cash balance. This "supplemental revenue" was allocated to the various vehicle classes in proportion to their net responsibility for its accumulation.

Comparison of Results with Other Studies

Over the four year study period, basic, intermediate, and heavy vehicles were found to be responsible for 64, 10, and 26 percent of the total state highway revenues. These results are consistent with those obtained in other states, as indicated by the comparison presented in Table 17. In reviewing the values reported in Table 17, it is important to note that methodologies and the meanings of parameters may vary between investigations. For example, the basic vehicle in the Oregon study was any vehicle with a weight of 6000 pounds or less (Oregon DOT, 1986). Nevada defined a basic vehicle as any vehicle weighing 6,000 pounds or less in their 1984 study (Nevada DOT, 1984), but they proceeded to change the definition in 1986 to any vehicle weighing 10,000 pounds or less (Nevada DOT, 1986). Naturally, even identical study methodologies yield different results between states, as the motor vehicle tax structures differ between states. Thus, the comparison of revenue allocation presented in Table 17 should only be evaluated from a very general perspective.

Table 17. Comparison of Revenue Allocation with Other Studies.

Study	Percent Allocation		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	64	10	26
Maine, 1989	70	16	14
Vermont, 1991	79	7	21
Nevada, 1984	74	26	
1986	66	34	
1988	59	41	
Oregon, 1986	53	47	
1991	58	42	

EXPENDITURE ALLOCATION

General Remarks

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of the expenditures on the highway system over the 4 year study period. Allocation of the expenditures on specific activities is summarized in Table 18. The specific allocation factors used for each expenditure item for each year of the study period are listed in Table 19. Primary areas of

Table 18. Summary of Expenditure Allocation.

Item	Avg. Annual Expenditures, FY 88-91	Allocation Methodology	% Basic	% Inter.	% Heavy
Motor Carrier Services Division Operations	$3,406,492	To non-basic vehicles, based on axle miles (cost to basic vehicles estimated to be less than 1/2 of 1 percent of total)	0	27	73
General Operations	7,496,138	To all vehicles based on VMT	84	7	9
Pre-Construction	5,055,263	To all vehicles based on VMT	84	7	9
Construction	63,098,174	Minimum facility to all vehicles based on VMT, Remainder to all vehicles based on ESAL-M (see also attached activity breakdown)	64	10	26
Maintenance	43,358,455	Primarily VMT to all, pavement costs based on environment vs. traffic related deterioration, environment VMT to all, traffic ESAL-M to all	66	8	26
Bond Interest	9,966,107	Allocated in same fashion as Construction costs	64	10	26
Dept. of Justice	10,384,727	To all vehicles based on VMT	84	7	9
Misc. Expenditures	(663,408)	To all vehicles based on VMT	84	7	9
TOTAL	142,101,946	-	**66**	**9**	**25**

Table 19. Summary of Expenditure Allocation by Study Year.

Expenditure	Allocation, 1988			Allocation, 1989			Allocation, 1990			Allocation, 1991			Over-all Allocation		
	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV	BV	IV	HV
M.C.S. Division Operations	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73	0.00	0.27	0.73
General Operations	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Pre-Construction	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Construction	0.65	0.09	0.26	0.65	0.09	0.26	0.61	0.10	0.29	0.66	0.10	0.24	0.64	0.10	0.26
Maintenance	0.69	0.08	0.22	0.64	0.09	0.27	0.64	0.08	0.28	0.65	0.09	0.26	0.66	0.08	0.26
Bond Interest	0.65	0.09	0.26	0.65	0.09	0.26	0.61	0.10	0.29	0.66	0.10	0.24	0.64	0.10	0.26
Dept. of Justice	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Miscellaneous Expenditures and Adjustments	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09	0.84	0.07	0.09
Total Expenditures	0.68	0.09	0.23	0.66	0.09	0.25	0.64	0.10	0.26	0.67	0.09	0.24	0.66	0.09	0.25

BV - Basic Vehicle
IV - Intermediate Vehicle
HV - Heavy Vehicle

expenditures include general and Motor Carrier Services Division operations, roadway construction and maintenance, law enforcement, and debt service. Expenditures were allocated to basic, intermediate, and heavy vehicles in accordance with the costs occasioned in providing equivalent service to all users. Different types of cost allocators were used on various expenditure items, depending on the activity involved and the type of vehicle demand being addressed. Activity costs that were independent of the specific vehicles involved were generally allocated based on VMT. Activity costs that were influenced by specific attributes of the vehicles involved were allocated, as possible, based on those attributes.

Allocation of Expenditures on General Operations

The general operating costs of MDT were allocated to all users based on VMT, and over the 4 year study period basic, intermediate, and heavy vehicles were found to be responsible for 84, 7, and 9 percent these expenditures. As the title implies, this category of costs covers expenditures related to the general operation of MDT and includes the costs of the Director's Office, general administration, personnel, accounting, planning, program development, building construction, and building maintenance.

M.C.S. Division Operations

Operation of the Motor Carrier Services Division of MDT was allocated to intermediate and heavy vehicles, only, based on AMT. Following this approach, intermediate and heavy vehicles were found to be responsible for 27 and 73 percent of these expenditures. The Motor Carrier Services Division of MDT is responsible for administering a variety of vehicle related fee programs and legislation enacted by the state of Montana (Motor Carrier Services Division, 1991). Activities of the division include the assessment and collection of gross weight fees, enforcement of vehicle weight and size restrictions (including weigh station operation), issuance of special overweight and oversize permits, etc. Most of the work done by the division is related to larger vehicles; work on matters related to basic vehicles is estimated to account for less than 1/2 percent of division expenditures (Galt, 1992). Thus, Motor Carrier Services division costs were allocated only to intermediate and heavy vehicles. AMT was selected as an appropriate cost allocator, as many fee and enforcement activities were axle, rather than vehicle, related.

Pre-Construction

The costs of preconstruction activities were allocated based on VMT. The specific activities grouped in this category include: engineering administration; project management; right-of-way procurement; and roadway, bridge, and traffic engineering. All these costs were assumed to be independent of the specific vehicle under consideration. Note that in some cost allocation studies, part of the right-of-way costs are allocated based on vehicle width, with the idea that wider vehicles require wider lanes and subsequently wider right-of-ways than basic vehicles (e.g., Nevada, 1984). In this study, however, it was decided that all vehicles share benefits from wide travel lanes, and thus VMT was an appropriate cost allocator.

Construction

Expenditures on highway construction and maintenance amounted to 75 percent of the total monies spent over the study period, and most of these expenditures were for work done on the primary rural system. MDT clearly differentiates between construction and maintenance activity costs for administrative purposes, and this same division in activities was followed in this study. In general, construction was defined as activities that resulted in a long term improvement in the level of service provided by a highway facility. Maintenance tasks were defined as those activities related to simply maintaining the level of service provided by an existing facility over the short term.

Basic, intermediate, and heavy vehicles were allocated 64, 10, and 26 percent of construction costs, respectively, over the study period. To allocate construction expenditures, a cost analysis was performed of all the construction projects let during the study period. Costs obtained from contract documents were regrouped by type of activity rather than individual project cost. The specific activity categories used in this study are listed in Table 20. Annual expenditures on each activity were assigned to basic, intermediate, and heavy vehicles using the allocators listed in Table 20. Note that activity costs were tabulated and allocated independently for each unit of the federal aid highway system. Thus, any differences in expenditure and use patterns on the various units of the federal aid system are accurately represented in these results. The total expenditure on each class of vehicle was calculated by summing the costs allocated to each class for each activity across all systems.

These analyses were performed using "as-bid" prices rather than actual construction costs. For this and other reasons, the sum of the expenditures assigned to each vehicle class nominally differed from the reported total construction costs. Therefore, the results of these analyses were used to calculate cost allocators to be used in assigning the actual construction costs to each vehicle class.

Table 20. Summary of Allocation of Construction Costs.

Activity	Percent of All Costs	Allocator
Contract Administration	9	VMT to all
Grading and Drainage	26	VMT to all
Pavement	51	
New Construction/Major Rehabilitation		Minimum facility cost, VMT to all Remaining cost, ESAL-M to all
Sub-Surface/Base		Minimum facility for basic vehicle, environment, and occasional heavy truck
Sub-Surface/Base, Treatments		
New Pavement		
Overlay		Minimum overlay cost, VMT to all Remaining cost, ESAL-M to all
Surface Prep, Existing Roadway		Minimum facility for basic vehicle, environment, and occasional truck (Surface prep cost, ESAL-M to all)
Overlay		
Seal Coats		VMT to all
Structures	3	
Bridges		New-Basic facility cost, VMT to all Remaining cost, TON-M to all, Basic facility cost, DL/TL * Total Cost Rehab-Non-structural costs, VMT to all Structural cost, TON-M to all Structural cost based on structural related loss of sufficiency rating
Weigh Stations/Scales		VMT to vehicles 10,000 lbs and greater
Roadside	1	VMT to all
Traffic	10	
Guard rails, traffic control, etc.		VMT to all
Traffic Control on Projects		VMT to all

These allocators were calculated as the ratio of the cost assigned to each vehicle class divided by the total assigned costs.

Reviewing Table 20, the costs of many of the construction activities were simply allocated based on VMT. The costs of all such activities were judged to be independent of the characteristics of the specific vehicles that used the highway. Activities related to paving and structures were allocated based on VMT and ESAL-M or AMT, as the effort required to provide these facilities was directly related to the configuration and weight of the vehicles to be served. Each construction activity is briefly described in the following paragraphs with comments, as appropriate, on the attendant cost allocator used. Note that construction engineering costs were prorated across all activities.

Contract Administration: As indicated by the title, this activity consists of the administrative tasks associated with conducting a construction project. This cost was shared between the three classes of vehicles based on VMT.

Grading and Drainage: This category of activities covers construction site work, exclusive of placing the base and the wearing surface (pavement). Major activities in this category of expenditures include (a) surveying, clearing, and grading the roadway, (b) excavating, placing, and backfilling drains and culverts, (c) constructing embankments and retaining walls, and (d) relocating storm drains and water and sewer lines. The costs of all these activities were allocated based on VMT. Once again, in some cost allocation studies, part of the site preparation costs are allocated based on vehicle width, under the premise that wider vehicles require a wider road and right of way. In this study, it was assumed that all vehicles realize advantages from wider roads, and thus costs are unrelated to any variations in width between conventional highway-size vehicles. Consideration was given to allocating some part of culvert costs based on vehicle weight. Discussions with the Hydraulics Division of MDT, however, revealed that culvert selection is rarely dictated by vehicle loads (Goodman, 1992).

Roadway: For new construction and major reconstruction, roadway activities consisted of sub-surface preparation and placement of the base and wearing surface. Part of the cost of these activities was allocated using VMT, while the remainder was allocated using ESAL-M.

Roadways deteriorate due to traffic loads and weathering/aging processes. From a cost allocation perspective

1) fixed costs involved in constructing the roadway should be shared by the various classes of vehicles based on VMT. Such costs, including equipment mobilization and other items, are clearly independent of the specific vehicles involved.

2) costs associated with vehicle related deterioration of the roadway should be allocated based on the physical demand various vehicles place on the roadway. These demands will generally determine the thickness of the base and wearing surface. To design the base and wearing surface, these demands are quantified in terms of total expected ESALs, as previously discussed. (Note that the width of the wearing surface, as it is related to the width of the vehicles being served, has been eliminated from consideration for reasons previously discussed.)

3) costs associated with weathering and aging related deterioration should be allocated based on VMT. These costs can be considered independent of vehicle configuration.

To meet these allocation objectives, roadway costs were divided into two components, (a) the cost of a basic facility with a 20 year design life to resist weathering and aging related deterioration and to carry predominantly basic vehicle traffic and an occasional heavy truck, and (b) the additional cost of providing a facility to carry the complete traffic stream. The cost of the basic facility was allocated to all vehicles using VMT. The additional cost of the full facility to carry the complete traffic stream was allocated based on ESAL-M.

To implement this allocation process, the MDT Materials Bureau designed basic facilities for each district in the state highway system to carry the average basic vehicle traffic observed on each unit of the federal aid system. In designing these basic facilities, the thickness of the running surface was held constant at 1.8 inches (the minimum thickness that presently can be placed) while the base thickness was varied from 4 inches to 18.5 inches in

response to changing subgrade conditions and vehicle loads. These basic facilities are described in detail in Appendix B. To simplify the allocation process, a single basic facility was developed for use across the entire state for each unit of the federal aid system. These facilities were determined by averaging the base thicknesses required in each district weighted by the miles of highway of that type in the district.

The costs of major pavement overlay projects were allocated to the various classes of highway users in a similar fashion as roadway construction and rehabilitation projects. The cost of a basic overlay was allocated to all users based on VMT while the costs of any additional thickness of overlay was allocated based on ESAL-M. While a basic overlay of 1 inch was theoretically adequate in all cases, the minimum thickness of overlay that could be practically placed was 1.8 inches (Stevenson, 1992).

For all construction projects, the estimated cost of the basic facility was subtracted from the reported cost of roadway activities to determine that portion of the costs to be allocated based on ESAL-M. For this purpose, the unit costs of the various basic facilities were estimated in 1991 dollars; unit costs for other years in the study period were estimated assuming a 4 percent inflation rate. If the minimum facility cost was greater than or equal to the reported actual base and wearing surface costs, all costs were allocated based on VMT.

Inherent in this approach to allocating base and wearing surface costs is the fundamental assumption that the primary purpose of the highway system is to serve basic vehicles, and that the extra costs of providing service to intermediate and heavy vehicles due to their increased demand on the system are added to the cost of providing service for basic vehicles. This assumption is somewhat supported by the traffic data, in that basic vehicles account for approximately 84 percent of system use based on VMT. While the increased demand by intermediate and heavy vehicles is significant (these vehicles account for approximately 88 percent of the ESAL-M), this demand can be met with a proportionally smaller increase than might be expected in the thickness of the base and wearing surface (the relationship between thickness and ESAL capacity is non-linear). Thus, if highway cost is expressed in terms of dollars per ESAL of demand, the unit cost of the added thickness of roadway to meet the demands of intermediate and heavy vehicles is lower than the unit cost of the initial thickness required to meet the demands of basic vehicles.

The approach to allocating roadway costs used in this study, described as a modified incremental approach, combines elements of two cost allocation methods commonly used in

studies of this type, namely, the Federal and Incremental Methods (Urban Institute, 1990; FHWA, 1984). The approach is patterned after that used by the state of Nevada in their cost allocation studies (Nevada DOT, 1984, 1986, 1988). With respect to roadway cost allocation, the Federal and Incremental Methods differ in the procedure and philosophy used to allocate the cost of vehicle related deterioration of the roadway. In the Federal approach, a basic facility is defined as the minimum facility that would be built independent of the level of traffic to be served. Such a facility could be considered as the basic facility required to resist weathering and aging deterioration over the design life of the pavement. The cost of such a facility is commonly shared by all users (VMT allocated). The additional cost of a facility designed to carry the expected traffic loads is shared among all users based on the level of demand they will place on the highway (ESAL-M allocated). Following this approach, the unit cost per ESAL of demand is the same for all users and all ESALs. Providing highway service to intermediate and heavy vehicles is thus treated as an integral part of the purpose of the highway system, instead of an add-on function.

Following the Incremental Method, highway costs and capacity are viewed incrementally. Users pay for all increments in system capacity required to meet their particular demands. In the case of roadway costs, all vehicles share in the cost of the first increment in capacity (the cost of a basic facility), while successive increments are shared only by the heavier vehicles that occasion them. The final increment of capacity is only paid for by the vehicles placing the highest demand on the system. Note that the unit costs of successive increments of service decrease (due to the non-linear relationship between the capacity of added increments of roadway thickness and the cost to provide them). The allocation method used in this study considers a basic facility and a single increment in capacity. All vehicles share the increment in capacity based on ESAL-M.

A simple illustration of roadway cost allocation using the three allocation methods discussed above is presented in Table 21. Some cost allocation studies present alternate solutions using the Federal and Incremental Methods. It is generally acknowledged that the Federal Method shifts more of the roadway costs from basic to heavy vehicles compared to the incremental methods. The costs allocated to basic vehicles are similar using the Incremental and modified incremental approaches. The modified incremental approach, however, results in the allocation of more of the non-basic vehicle costs to heavier vehicles compared to the results obtained using the Incremental Method.

Table 21. Illustration of Different Methods for Allocating Roadway Costs.

(a) Assumed Vehicle Use

Vehicle Class	System Use (Annually)		
	Vehicle Trips	Tons	ESALs
Basic	217,000	416,424	217
Intermediate	18,791	144,917	4,182
Heavy	23,123	641,998	34,820
All	258,914	1,203,339	39,219

(b) Characteristics of the Roadway

Roadway Being Considered	Required Base Thickness	Wearing Surface	Estimated Cost, 32 ft Width, 1 mile
Minimum Facility, Independent of Vehicle Use	3.5	1.8	65,055
Basic Facility, Service to Basic Vehicles Only	8.0	1.8	94,389
Intermediate Facility, Service to Basic and Intermediate Vehicles	23.0	1.8	192,167
Full Facility, Service to All Vehicles	30.0	1.8	237,797

(c) Allocation of Cost

Vehicle Class	Cost Responsibility in Thousands of Dollars								
	Modified Incremental Method			Federal Method			Incremental Method		
	VMT	ESAL	Total	VMT	ESAL	Total	VMT	TMT	Total
Basic	79.1	0.8	79.9	54.5	1.0	55.5	79.1	0.0	79.1
Inter.	6.9	15.3	22.2	4.7	18.4	23.1	6.9	18.0	24.9
Heavy	8.4	127.3	135.7	5.8	153.4	159.2	8.4	125.3	133.7
All	94.4	143.4	237.8	65.0	172.8	237.8	94.4	143.3	237.8

Structures: Bridge projects were divided into two categories, namely, construction (new and replacement) and rehabilitation. Bridge construction costs were allocated to the various vehicle classes based on VMT and TMT. Rehabilitation costs were allocated based on VMT. The intent of the allocation process was to assign (a) common costs (costs independent of the specific vehicles being served) based on VMT and (b) costs incurred to carry specific vehicle loads based on TMT.

Bridges are designed to carry a variety of loads, including their self weight (dead load), the weight of vehicles on the bridge (live load), any enhancement of vehicle loads due to dynamic effects (impact load), wind loads, and loads induced by earthquakes. Often, the over-all design of a bridge is controlled by the magnitudes of the dead load and the live and impact loads. The magnitudes of the live and impact loads are directly related to the weight of the vehicles the bridge is designed to serve. Thus, the costs associated with carrying live and impact loads were allocated based on vehicle weight (i.e., using TMT). All other costs were shared by all vehicle classes based on VMT.

That part of the bridge construction costs to be allocated based on VMT was calculated by multiplying the dead load to total load ratio for the bridge by the total construction cost. The remaining cost was presumed to be live and impact load related, and this cost was allocated based on TMT. This approach was used as an alternative to the costly process of designing minimum bridge facilities (to carry dead load only) to determine that part of bridge construction costs to be allocated based on VMT. This approach was reportedly first used by the state of Nevada in their cost allocation study (Nevada, 1984).

The Bridge Bureau at MDT determined the dead load to total load ratios used in this study by reviewing the design documents from every bridge constructed during the study period. Following the approach successfully used by the state of Nevada (Nevada DOT, 1984), dead load to total load ratios were determined for each bridge independently for the substructure and superstructure, which were then averaged to obtain a composite ratio for the bridge. For each major unit of the federal aid system, the dead load to total load ratios were weighted by the associated bridge lengths to obtain an average ratio to be used across that unit of the system. These ratios are presented in Table 22.

Bridge rehabilitation costs were allocated to the vehicle classes based on VMT. Structural condition was the only cause for bridge rehabilitation judged to be directly related to a specific vehicle attribute (weight). The structural adequacy of fifty-eight of the 61

Table 22. Dead Load to Total Load Ratios for Bridges.

System	Dead Load to Total Load Ratio
Interstate	*0.85
Primary	0.75
Secondary	0.77
Urban	**0.76
Off-System	0.61

Source: Bridge Bureau, MDT (Murphy, 1992)
* Based on a single bridge
** Based on two bridges

bridges rehabilitated during the study period was the same before and after rehabilitation (Murphy, 1992).

Roadside: Activities in this category are primarily "landscaping" related, e.g., sprinkler systems, sodding, seeding, wetlands development, etc. Costs of these activities were VMT allocated.

Traffic: Activities in this category are related to controlling and directing vehicles, and include placing signs, guardrails, signals, etc. Costs of these activities were allocated based on VMT.

Maintenance

Basic, intermediate, and heavy vehicles were allocated 68, 8, and 26 percent, respectively, of the maintenance expenditures on the highway system. These costs were primarily allocated using VMT and ESAL-M, based on the specific tasks being considered. The categories of maintenance activities used in this study are listed in Table 23. Annual expenditures on each type of activity were obtained by analyzing accounting information provided by the Maintenance and Equipment Bureau of MDT. The expenditures on each activity were assigned to the various vehicle classes using the allocators indicated in Table 23. Activity costs were tabulated and allocated independently on each of the major units of the federal aid system.

Table 23. Summary of Allocation of Maintenance Costs.

Activity	Percent of All Costs	Allocator
Roadway	25	Pavement related activities in this category Environmental, VMT to all Traffic related, ESAL-M to all (Split, environmental vs. traffic 20/80 interstate, 40/60 for all other systems)
Roadside	5	VMT to all
Drainage	2	VMT to all
Bridges	1	VMT to all
Facilities	7	VMT to all
Traffic Safety	11	VMT to all
Winter Maintenance	17	VMT to all, except sanding and deicing by AMT
Materials Production/Handling/Stockpiling	19	Cost to be split by environmental vs. traffic factor as for pavement activities above
Equipment/Supervision/Overhead	13	VMT to all

The following paragraphs include a brief description of the activities included in each maintenance category and a discussion, as appropriate, of the selected allocation process.

Roadway: Maintenance activities on the roadway primarily consisted of patching and sealing the wearing surface and the placement of thin overlays. Deterioration of seal coats was judged to be related to the number of axle passages over the roadway, and these costs were allocated to all vehicles based on AMT. The costs of patching and overlays were divided into two categories, (a) expenditures caused by traffic related deterioration of the roadway and (b) costs occasioned by weathering and aging related deterioration of the roadway. The costs of traffic related deterioration were allocated based on the demand specific vehicles placed on the roadway as measured in ESALs. The costs associated with weathering and aging related deterioration of the roadway were allocated based on VMT.

The basic division of roadway costs into traffic and weathering/aging related components was determined by estimating the underlying amount of deterioration attributable to each cause. Surveys conducted in other cost allocation studies and guides (Oregon DOT, 1986; Urban Institute, 1990) found that the relative amount of pavement damage assigned to traffic and allocated based on ESAL-M ranged from 54 to 98 percent (see Table 24). Note that many of these estimates were based on expert opinion, rather than rigorous tests. A general consensus does exist that the relative amount of traffic versus weathering/aging damage is influenced by specific climatic conditions, type of pavement, and the volume and type of traffic. Generally, as the volume of traffic (e.g., expressed in ESALs per day) increases, the proportion of damage attributable to environmental factors decreases.

Table 24. Weathering/Aging and Traffic Related Deterioration of Highways

Study	Percent of Pavement Maintenance Costs Allocated Based on ESAL-M
Indiana (1984)	
Northern	66-87
Southern	70-98
Iowa (1983)	
Interstate	90
Surfaced	80
Unsurfaced	50
Maryland (1982)	75
Nevada (1984)	75
Oregon (1980)	90
Vermont (1990)	73
Virginia (1980)	
Interstate	77
Primary	66
Secondary	54

Source: Surveys of maintenance cost allocation given in: Urban Institute (1990), Oregon DOT (1986)

After a review of the various factors presented in Table 24, traffic was assigned responsibility for 80 percent of the roadway deterioration on the interstate system; weathering and aging, 20 percent. On all other systems, traffic was assigned responsibility for 60 percent of the roadway deterioration; weathering and aging, 40 percent. The volume of traffic on the interstate (measured in ESALs/day) is over five times greater than that on any other unit of the federal aid system. Thus, traffic related damage was assessed a higher percentage of the total roadway damage on the interstate versus other systems. Traffic on the other units of the highway system was judged to be generally less than the traffic on comparable highways in all other states included in Table 24, and therefore traffic was only assigned responsibility for 60 percent of the observed pavement damage on these highways.

Roadside: Roadside activities, allocated based on VMT, consisted of mowing, brush and tree cutting, litter pickup, fence and gate repair, etc.

Drainage: This category of activities included cleaning, repairing, and replacing drainage facilities such as culverts and ditches. The costs of these activities were allocated based on VMT.

Bridges: Bridge maintenance costs were allocated based on VMT. A discussion with the maintenance personnel indicated that only minor work was done on bridges as a maintenance activity. All major work that significantly impacted functional capacity was done as a construction activity.

Facilities: Work on rest area and maintenance facilities was included in this activity category. The costs of these activities were allocated based on VMT.

Traffic Safety: This category of activity consists of the repair and replacement of signs, signals, lighting, guardrails, etc. The costs of these activities were allocated based on VMT.

Winter Maintenance: Winter maintenance costs included the costs associated with snow removal, sanding, de-icing, etc. These costs were shared between all users based on VMT, with the exception of sanding and deicing costs, which were allocated based on AMT.

Equipment/Supervision/Overhead: Costs of equipment maintenance, administration, training, and other miscellaneous activities were included in this activity category. These costs were allocated based on VMT.

Bond Principal and Interest

Expenditures related to the $97,000,000 in principal raised through bond sales in 1987 are included in two entries in the cash flow sheet. Revenue raised from the bond sales was to be used in construction projects; thus some of the indicated construction expenditures were bond funded. Additionally, repayment of the bond principal, with interest, is directly included as an entry in the expenditure summary. From a cost responsibility perspective, expenditure of the principal should only be allocated to the various classes of users once, either as a construction expenditure or as debt retirement (otherwise, more money is being allocated than was actually collected). The decision was made to consider the costs of bond funded construction in the allocation process and omit bond principal repayment. Interest payments on the bond proceeds, however, were assigned to the various vehicle classes using the construction cost allocators, consistent with the manner in which the principal was spent. Note that over the four year study period, only interest payments were made on the bond issue, none of the principal was repaid.

Department of Justice

The State Highway Patrol, under the auspices of the Department of Justice, is funded with highway revenues. Expenditures for the highway patrol were shared between the three vehicle classes based on VMT.

Miscellaneous Expenditures

Miscellaneous expenditures included accounting adjustments and nominal payments to the Department of Fish, Wildlife, and Parks ($29,735 over the entire study period) for road work.

Comparison of Results with Other Studies

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of the total expenditures on the highway system over the 4 year study period. These results are compared with the results obtained in other studies in Table 25. The results from this study fall within the results obtained in those studies. In evaluating the comparison presented in Table 25, it is

important to note that significant variations do exist in the highway system requirements and associated highway expenditures between states, and that the methodology used in allocating these expenditures may vary between studies.

Table 25. Comparison of Expenditure Allocation with Other Studies.

Study	Percent Allocation		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	66	9	24
Maine, 1989	70	17	13
Vermont, 1991	79	6	15
Nevada, 1984	64	36	
1986	64	36	
1988	59	41	
Oregon, 1986	59	41	
1991	62	38	

COMPARISON, REVENUE AND EXPENDITURES

General Remarks

One useful method to report the results of a cost allocation study is in the form of equity ratios. An equity ratio is defined as the ratio of the percentage of revenue allocated to a vehicle class divided by the corresponding percentage of allocated expenditures. An equity ratio greater than one indicates that vehicle class is overpaying for its use of the highway system compared to other vehicle classes; correspondingly, an equity ratio less than one indicates relative underpayment by a vehicle class for its use of the highway system. It is important to recognize that equity ratios only indicate relative overpayment or underpayment by various highway users, not absolute underpayment or overpayment for the highway system. In the last two years of the study period, for example, highway expenditures exceeded revenues, indicating all users may possibly be underpaying the state for the highway system.

While the principal intent of this part of this investigation was to determine the relative equity of the existing payments made by various classes of vehicles for their use of the highway system, general approaches were explored for remedying the inequities in these payments that were identified herein. The analyses performed on past revenues and expenditures in support of the basic cost allocation study were used to evaluate the influence of changes in revenues and expenditures on the equity situation. Note that only inequities between the classes of vehicles considered in the cost allocation study (basic, intermediate, and heavy vehicles) could be addressed in these analyses. Additional cost allocation analyses will have to be performed to identify relative equity differences between vehicles within each class, before more refined changes in the revenue and expenditure situation can be evaluated (such analyses are presently underway). Further note that possible changes in highway use precipitated by changes in fees and charges to use the highway system were not considered in assessing the impact of such changes on the equity situation.

Equity Ratios

The average equity ratios determined in this investigation over the 4 year study period for basic, intermediate, and heavy vehicles were 0.96, 1.11, and 1.07, respectively. Thus, basic vehicles were found to be relatively underpaying for their use of the highway system, while intermediate and heavy vehicles were found to be overpaying for their use of the highway system.

The equity ratios calculated for the 3 classes of vehicles for each year of the study period are presented in Table 26. In each year of the study, basic vehicles had the lowest equity ratio; intermediate vehicles, the highest equity ratio. The equity ratio for basic vehicles steadily increased for the first three years of the study period, reaching a peak of 0.99 in 1990, and then declined to 0.97 in 1991 (the last year included in the study). The equity ratios for intermediate and heavy vehicles steadily decreased for the first three years of the study period, dropping in 1990 to 1.06 and 1.00, respectively. This trend reversed between 1990 and 1991, as the equity ratios for intermediate and heavy vehicles increased to 1.10 and 1.05, respectively.

Based on the results presented in Table 26, it is difficult to exactly predict future equity ratios. The reversal in the steady trend in the equity ratios observed for all vehicle classes between 1990 and 1991 cannot be reliably predicted to continue in 1992 and subsequent years, based on the limited data available. None-the-less, it can be predicted that radical changes in the magnitudes of the equity ratios over the next few years are unlikely, in that the changes in the ratios between consecutive years of the study period were a maximum of 8 percent and averaged only 5 percent. Furthermore, the relative magnitudes of the equity ratios of the various vehicle classes can be expected to remain the same in the future, that is, basic vehicles can be expected to continue to have the lowest equity ratios; intermediate vehicles, the highest equity ratios.

Comparison of Results with Other Studies

The equity ratios obtained in this study are consistent with those obtained in other studies, as indicated by the limited survey of such results presented in Table 27. The results presented in Table 27 indicate the wide range of equity situations that exist in various states between classes of vehicles. Once again, the information presented in Table 27 should be viewed only from a general perspective, in that motor vehicle tax revenues and highway expenditures vary between states, and the manner in which these revenues and expenditures were analyzed may vary between studies.

Equity Adjustments

The analysis program developed to allocate historical revenue and expenditure data was used to evaluate the effect of changes in the revenue/expenditure structure on the equity ratios for the vehicle classes. Tentative efforts were made to change the structure to improve relative equity between the vehicle classes. The simplest and most direct improvement was obtained by increasing

Table 26. Comparisons, Allocated Revenue and Expenditures.

Fiscal Year	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
1988			
Revenue, Percent	63.5	10.5	26.0
Expenditures, Percent	68.2	9.0	22.8
Equity Ratio	0.93	1.16	1.14
1989			
Revenue, Percent	62.4	10.5	27.1
Expenditures, Percent	65.8	9.2	25.0
Equity Ratio	0.95	1.14	1.09
1990			
Revenue, Percent	63.4	10.3	26.3
Expenditures, Percent	63.9	9.7	26.4
Equity Ratio	0.99	1.06	1.00
1991			
Revenue, Percent	64.8	10.3	24.9
Expenditures, Percent	66.9	9.4	23.8
Equity Ratio	0.97	1.10	1.05
Over All Years			
Revenue, Percent	**63.5**	**10.4**	**26.1**
Expenditures, Percent	**66.2**	**9.3**	**24.5**
Equity Ratio	**0.96**	**1.11**	**1.07**

the new vehicle sales tax by 400 percent. Equity ratios close to 1.0 were generated for all three classes of vehicles by this action. Alternatively, increasing the gasoline tax 22.5 percent, from $0.20 to $0.245 per gallon, improved the equity situation between basic and heavy vehicles. This change resulted in equity ratios of 0.986 and 0.982 for basic and heavy vehicles, respectively. This change, however, had a negative impact on the equity ratio for intermediate vehicles, increasing this ratio from 1.11 to 1.14. This situation was improved by reallocating the gross weight fees paid by the various vehicle classes to reduce the responsibility of intermediate vehicles for such payments.

Table 27. Comparison of Equity Ratios with Other Studies.

Study	Equity Ratio		
	Basic Vehicles	Intermediate Vehicles	Heavy Vehicles
Montana, 1992	0.96	1.11	1.07
Maine, 1989	0.99	0.96	1.09
Vermont, 1991	1.02	1.11	0.92
Wyoming, 1981*	1.00	1.26	1.20
Nevada, 1984	1.11	0.74	
1986	1.03	0.95	
1988	1.00	1.00	
Oregon, 1986	0.90	1.15	
1991	0.94	1.11	

* values estimated from information presented in cost allocation study and normalized to 1.00 for basic vehicles

Increasing basic vehicle contributions was judged to be a prudent approach to address the cost inequities identified in this study. The major inequity revealed by the study was the relative underpayment of basic vehicles and overpayment of intermediate and heavy vehicles for their use of the highway system. Approaches considered to alleviate this inequity consisted of adjusting the relative revenues and expenditures associated with each vehicle class. Highway expenditures and their allocation to various users are generally fixed by the physical requirements of providing equivalent service to all users. Thus, highway revenues were selected for adjustment in addressing inequities in user payments. To alleviate the particular inequities in user payments identified in this study, more revenue needed to be allocated to basic vehicles relative to intermediate and heavy vehicles. This reallocation could have been accomplished by increasing basic vehicle contributions, decreasing intermediate and heavy vehicle contributions, or both. Increasing revenue was deemed appropriate, in that total revenue was less than total expenditures during the last two years of the study period.

Sources of revenue dominated by basic vehicle contributions (followed by heavy vehicle contributions) were initially considered in the equity adjustment process. Reviewing Table 6, such sources were found to consist of the new vehicle sales tax, contributions from the Coal Tax Trust Fund, bond proceeds and earnings, and miscellaneous accounts receivable. Of these various revenue

sources, the new vehicle sales tax was selected as possibly most appropriate for modification. The revenue generated by this tax, however, was sufficiently low that a major change in the tax rate was necessary to significantly impact the overall equity ratios. A uniform 400 percent increase in the new vehicle sales tax resulted in equity ratios for all 3 vehicle classes between 0.98 and 1.01.

Alternatively, revenue sources were searched for that consisted primarily of basic vehicle contributions and that constituted a significant portion of the total highway revenues collected. The gasoline tax fit these parameters. Increasing the gasoline tax by only 22.5 percent resulted in equity ratios of 0.986 and 0.982 for basic and heavy vehicles, respectively. Unfortunately, intermediate vehicles paid substantial gasoline taxes, and thus their overall equity ratio increased from 1.11 to 1.14 in response to this gas tax increase. Attempts were made to offset this increase in the intermediate vehicle equity ratio by reallocating other revenue. A reduction of intermediate vehicle gross weight fees was considered with an attendant increase in basic vehicle and heavy vehicle fees. Reassigning all the gross weight fees paid by intermediate vehicles to basic and heavy vehicles still resulted in an equity ratio for intermediate vehicles of 1.03. Alternatively, gross weight fees for basic and heavy vehicles could simply have been raised. Increasing the diesel fuel tax improved the equity situation between intermediate and heavy vehicles, but this approach further reduced the equity ratio for basic vehicles.

Eventually, the decision was made to postpone further attempts to improve the equity situation between vehicle classes until a more comprehensive review of the motor vehicle tax structure could be completed.

SUMMARY AND CONCLUSIONS

Summary and Conclusions

The results of this cost allocation study, conducted on state revenue and expenditures on the highway system, indicate that basic vehicles are relatively underpaying for their use of the system while intermediate and heavy vehicles are relatively overpaying for their use of the system. Equity ratios were determined for each vehicle class by dividing the percentage of highway revenue assignable to each vehicle class by the associated expenditures involved in providing that class of vehicles with highway service. The equity ratios determined herein for a four year study period ending in 1991 were 0.96, 1.11, and 1.07, respectively, for basic, intermediate, and heavy vehicles. Approaches to improving the equity situation between vehicle classes were tentatively investigated. These approaches included (a) increasing the new vehicle sales tax (by 400 percent) or (b) increasing the gasoline tax (by 22.5 percent) in conjunction with altering other fees. Specific recommendations for changing the motor vehicle fee structure were deferred until a more thorough review of the tax structure is completed.

The equity ratios presented above were determined by analyzing revenue and expenditure data for the state highway system over the period from 1988 to 1991. The purpose of this analysis was to allocate all revenues and expenditures to the various classes of vehicles that use the highway system. Only state revenues and expenditures were considered. Fees paid to the federal government and federal expenditures on the highway system were not considered in the study. Revenues and expenditures were assigned to 3 broad classes of vehicles, namely, basic vehicles (gross weight of less than 10,000 pounds), intermediate vehicles (2 axle single units with gross weights greater than or equal to 10,000 pounds but less than 26,000 pounds and busses) and heavy vehicles (3 or more axle single units and all combinations).

This study determined that basic, intermediate, and heavy vehicles were responsible for 64, 10, and 26 percent of highway revenues. These revenues primarily consisted of fuel taxes, new vehicle sales taxes, gross weight fees, bond proceeds and interest, and proceeds from the Coal Tax Trust Fund. Revenue directly derived from users was allocated to the various vehicle classes in the manner in which it was collected. Revenue from general sources (e.g., bond proceeds and interest) was shared between vehicle classes based on their relative use of the highway system, consistent with the philosophy that the intent of such funding was to provide equal benefit and service to all users.

Basic, intermediate, and heavy vehicles were found to be responsible for 66, 9, and 25 percent of highway expenditures, respectively. These expenditures primarily consisted of the general operation of the Department of Transportation, operation of the Motor Carrier Services Division, and highway construction and maintenance. Different methods were used to allocate these costs based on the specific tasks under consideration. The costs of activities that were independent of the specific vehicles being served were allocated based on the relative miles travelled by each class of vehicles. Costs that were influenced by attributes of the specific vehicles being served were allocated, as possible, based on that attribute. Roadway (base and wearing surface) construction and maintenance costs were the primary expenditures on the highway system. Roadway construction costs were allocated using a modified incremental approach in which all vehicles shared the cost of a facility to provide service for basic vehicles based on vehicle miles travelled. The remaining cost of the full facility was allocated based on ESAL miles travelled. Pavement maintenance costs were split between costs related to traffic damage and costs related to weathering and aging damage. Traffic related costs were allocated to all users based on ESAL miles travelled; weathering/aging related costs, based on vehicle miles travelled.

Recommendations for Future Studies

The cost allocation study should be updated at regular intervals to reflect changes in traffic patterns, funding levels, and expenditure philosophies. Oregon and Nevada, for example, update their studies every 2 years. The results of the Nevada studies are used by the state legislature in evaluating revisions to the motor vehicle tax structure. Revision of the Montana study will be appropriate within two years due to,

(a) the reorganization of the federal aid highway system under the new Surface Transportation Act and the attendant change in federal cost share ratios and total federal dollars available for highway construction.

(b) the emerging fiscal trend of state highway expenditures exceeding annual revenue. Over the four year study period, the cash flow balance at the end of each year steadily eroded from a surplus of $15,005,460 in 1988 to a deficit of $39,238,516 in 1991. This situation will force a change to occur in either the motor vehicle revenue structure or the level of expenditures on the highway system.

In preparing an update to the study, the opportunity may exist to expand the depth of the investigation and to refine the methodology employed. It would be informative to perform additional

analyses using alternate allocation strategies for those revenue and expenditure items which can be reasonably allocated in several ways. Construction expenditures on the base and wearing surface of the roadway are an example of such an item. These expenditures have been variously allocated in state cost studies using the federal, incremental, and modified incremental approaches (as previously discussed). The influence of the approach selected for allocation of these costs on the final results of the study has been significant in some investigations. Additional research should also be done on the sensitivity of the study results to specific assumptions made in the allocation process. Such information would reveal the areas that should first receive attention in any future efforts to improve the study results. One such assumption, for example, is the split assumed between traffic and weathering/aging related deterioration of the roadway wearing surface that is used in allocating maintenance costs. It may be possible to more definitively establish this value than was done in this study by rigorously reviewing the available information on the subject, conducting a survey of maintenance experts around Montana, etc. Such efforts would only be justified, however, if this value has a significant influence on the study results.

The cost allocation analyses conducted herein can possibly be modified to better predict the future equity situation than is presently being done. MDT generates a cash flow table of projected revenue and expenditures similar to the historical cash flow table upon which this study is based. Assuming that highway use and needs are relatively stable, the allocators developed in this study can be applied to future revenues and expenditures to obtain an approximate indication of the future equity situation. Such information might be useful in evaluating any contemplated changes to the motor vehicle tax structure.

The results of this and future cost allocation studies are only as reliable as the data upon which they are based. Generally, excellent data was available from MDT to support this study. Specific changes that would facilitate and improve future studies include:

1) collection of more traffic data on the secondary system (although expenditures on this system represent only a small fraction of the total fiscal situation) and
2) better identification of the specific sources of new vehicle sales tax revenue and gross vehicle weight fees.

The latter change is essential, if the cost allocation study is to address equity between vehicle types within each major user class. The addition of cost allocation identifiers to the accounting systems used to track construction and maintenance costs would facilitate the processing of this information. The required data processing, however, can be reasonably accomplished using the present systems.

With-in the framework of the existing study, some of the revenue and expenditure items presently assigned in a lump sum fashion could possibly be broken down in future studies into their constituent elements and allocated at that level (e.g., miscellaneous fees collected by the M.C.S. division and miscellaneous accounts receivable). While individual refinements of this kind will only have a small impact on the study results, their net effect could be significant.

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APPENDIX A

Cash Flow Table, MDT, FY 1987 - 1991

This appendix contains the original cashflow table provided by the Financial Management Bureau of the Montana Department of Transportation listing the highway system expenditures and revenues upon with this cost allocation study is based.

MONTANA DEPARTMENT OF TRANSPORTATION
ACTUAL CASH FLOW
FY '87 - FY '91

	FY '87	FY '88	FY '89	FY '90	FY '91
BEGINNING WORKING CASH BALANCE	$45,286,748	$126,618,131	$140,748,187	$145,538,177	$129,627,153
REVENUE					
G.V.W.	22,263,806	23,967,756	25,280,566	26,739,312	25,177,590
Gas Tax	66,608,309	79,675,077	82,691,513	82,297,751	81,146,066
Diesel Tax	17,541,396	21,185,520	22,708,492	23,821,548	22,797,863
Accounts Receivable	1,229,343	2,213,013	2,107,333	4,978,078	3,784,789
Coal Tax	5,940,016	10,156,597	7,027,869	8,144,464	6,054,941
Bond Interest Earnings	1,216,004	9,053,452	6,200,687	3,925,575	725,549
Bond Proceeds	97,657,126	26,701	0	0	0
Stores	10,065,499	11,375,963	12,095,355	13,605,350	12,950,817
OTHER:					
Dept. of Justice	0	0	0	20,366	33,363
ACI Reimbursement	10,935,298	7,489,996	0	0	0
Prior Year Revenue Adj.	417,229	(118,859)	(31,372)	(86,319)	(144,359)
TOTAL REVENUE	$233,874,026	$165,025,216	$158,080,443	$163,446,125	$152,526,619
AVAILABLE WORKING CASH	$279,160,774	$291,643,347	$298,828,630	$308,984,302	$282,153,772
EXPENDITURES					
G.V.W.	3,255,720	3,392,515	3,377,012	3,370,452	3,485,987
General Operations	4,627,146	5,055,256	4,773,934	6,075,639	6,256,817
Construction	17,339,253	25,927,493	28,316,283	12,972,429	33,334,624
Maintenance	38,165,557	40,968,264	42,121,180	44,480,936	45,863,441
Preconstruction	6,096,939	3,847,939	4,607,207	5,028,133	6,737,771
Equipment	2,247,850	1,930,659	800,000	0	0
Headquarters Building	224,067	596,085	549,402	525,821	528,899
A. & E.	464,646	1,143,947	716,699	457,942	573,450
Local Government	14,144,825	14,146,250	14,146,250	14,146,248	14,146,250
Bond Principal & Interest	15,069,700	10,041,082	10,041,083	10,041,083	9,741,178
Reconstruction Trust	30,632,131	21,072,047	25,952,555	41,025,782	48,379,609
Motor Fuels	0	0	0	0	713,293
Dept. of Revenue	737,870	783,472	737,832	696,250	0
Dept. of Justice	9,200,816	9,708,600	9,957,471	10,885,348	10,987,488
Stores	10,464,022	12,244,376	11,910,013	13,209,039	13,288,393
Bond 4 ACI Const.	0	0	1,741,119	0	0
Bond 4 SS Const.	0	0	17,326,907	16,343,848	0
Dept. of Fish Wildlife & Parks	0	0	0	0	29,735
Entity Adjustment	(465,944)	(304,359)	(3,638,270)	83,756	(126,718)
Prior Year Adjustment	338,045	341,534	(146,224)	14,443	(1,838,376)
TOTAL EXPENDITURES	$152,542,643	$150,895,160	$153,290,453	$179,357,149	$192,101,841
ENDING WORKING CASH BALANCE	$126,618,131	$140,748,187	$145,538,177	$129,627,153	$90,051,931

APPENDIX B

Basic Facility Definitions, Base and Wearing Surface

Included in this appendix are the basic facility designs used in allocating highway construction costs for the base and wearing surface.

Montana Department of Transportation
Helena, Montana 59620

Memorandum

To: Bill Cloud, Chief
Passenger Transportation Bureau

Thru: Kenneth H. Neumiller, Supervisor
Materials Services Section

From: James R. Stevenson, Manager
Pavement Analysis Unit
Materials Bureau

Date: April 3, 1992

Subject: Minimum Facility Design

As per Jerry Stephens' request, please find a copy of the new Construction and Overlay Minimum Facility Designs attached. Included is a list of all assumptions needed for the mechanistic design and cost analysis.

JS:D:MT:40.dr

Attachment

cc: Ken Neumiller
James Stevenson

THIS PACKET MAILED TO JERRY STEPHENS 4/6/92.

NEW CONSTRUCTION MINIMUM FACILITY DESIGN

UTE TYPE	THICKNESS	REGION 1	REGION 2	REGION 3	REGION 4	REGION 5
ONDARY	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	4.0	4.0	5.0	7.5	5.0
	COST/MI	61,500	61,500	68,000	86,000	67,000
MARY RURAL	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	5.0	6.0	8.0	11.0	9.0
	COST/MI	77,500	85,500	110,000	126,000	109,000
ERSTATE RURAL	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	7.0	8.5	11.5	15.5	12.0
	COST/MI	214,000	221,000	292,000	365,000	301,000
AN	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	8.5	10.5	13.5	18.5	15.0
	COST/MI	133,000	150,000	181,500	234,5000	198,000
ERSTATE URBAN	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	10.0	12.0	15.0	20.5	16.5
	COSTMI	265,000	301,000	355,500	461,000	383,500
MARY URBAN	PMS	1.8	1.8	1.8	1.8	1.8
	CBC	11.5	13.5	17.5	24.0	18.5
	COST/MI	131,000	149,000	187,500	257,500	198,000

MINIMUM FACILITY OVERLAY DESIGN

E OVERLAY FOR THE MINIMUM FACILITY IN ALL REGIONS AND CLASSIFICATIONS
ULD BE LESS THAN 1 INCH , HOWEVER STANDARD CONSTRUCTION PRACTICES WOULD
QUIRE 1.8 INCHES

MINIMUM FACILITY DESIGN ASSUMPTIONS

ANNUAL ESALs	NEW CONSTRUCTION	OVERLAY
SECONDARY	70	105
PRIMARY RURAL	217	292
INTERSTATE RURAL	558	960
URBAN	981	1772
INTERSTATE URBAN	1278	2801
PRIMARY URBAN	1901	2966

PLANT MIX MODULUS (FOR ALL REGIONS) - 350000

BASE GRAVEL MODULUS - REGION 1 - 28000
REGION 2 - 28000
REGION 3 - 25000
REGION 4 - 22000
REGION 5 - 25000

SUBGRADE MODULUS REGION 1 - 12000
REGION 2 - 10000
REGION 3 - 8000
REGION 4 - 6500
REGION 5 - 7500

DESIGNED USING THE MICHPAVE ANALYSIS PROGRAM (LINEAR ANALYSIS)

3 LAYER ANALYSIS

10000 LBS MAXIMUM WHEEL LOAD

100 PSI TIRE PRESSURE

AVERAGE ANNUAL TEMPERATURE - 50 (FAHRENHEIT)

PERCENT AIR VOIDS IN PMS - 5 %

KINEMATIC VISCOSITY (85 - 100) 270

POISSON'S RATIO - PLANT MIX - .40
BASE GRAVEL - .42
SUBGRADE - .45

DENSITY - PLANT MIX - 150
BASE GRAVEL - 125
SUBGRADE - 115

Ko - PLANT MIX - 2.5
BASE GRAVEL - 1.5
SUBGRADE - 0.8

REGIONS BASED ON THE 5 DISTRICTS

COST ASSUMPTIONS - PLANT MIX - $45/cu yd
BASE GRAVEL - $12.50/cu yd

PAVEMENT WIDTH - SECONDARY - 28 FT
PRIMARY RURAL - 32 FT
INTERSTATE RURAL - 76 FT
URBAN - 40 FT
INTERSTATE URBAN - 76 FT
PRIMARY URBAN - 32 FT

NOTE: WIDTHS AS PER RECOMMENDATIONS FROM S.C. KOLOGI ON 4/2/92.

TIM - GIVE DATA BETTER

BILL - SECONDARY FOR TIM'S BETTER